SCIENTIFIC AMERICAN SUPPLEMENT. No. 1759

Entered at the Post Office of New York, N. Y., as Second Class Matter.
Copyright, 1909, by Munn & Co., Inc.
Published weekly by Munn & Co., Inc., at 361 Broadway, New York.
Charles Allen Munn, President, 361 Broadway, New York.
Frederick Converse Beach, Sec'y and Treas., 361 Broadway, New York.

Scientific American, established 1845.
Scientific American Supplement, Vol. LXVIII., No. 1759.
NEW YORK. SEPTEMBER 18. 1909.
Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.

THE RHEIMS AVIATION MEETING.

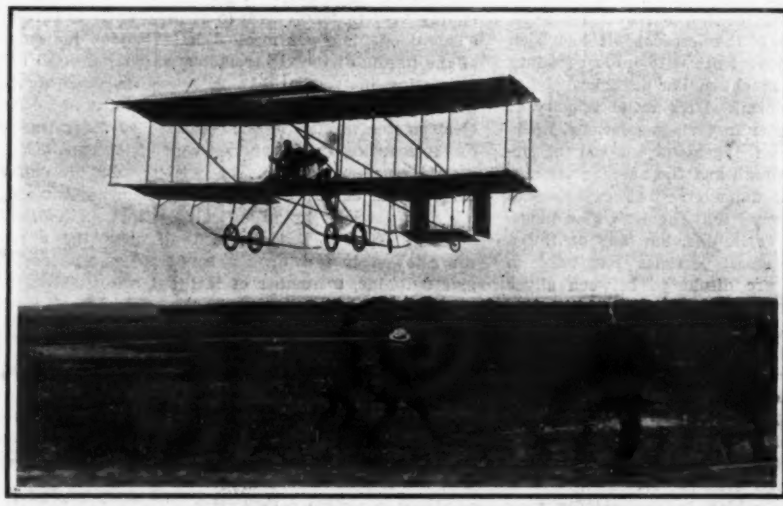
DETAILS OF THE FIRST GREAT EXHIBITION OF DYNAMIC FLIGHT.

THE OPENING DAY.

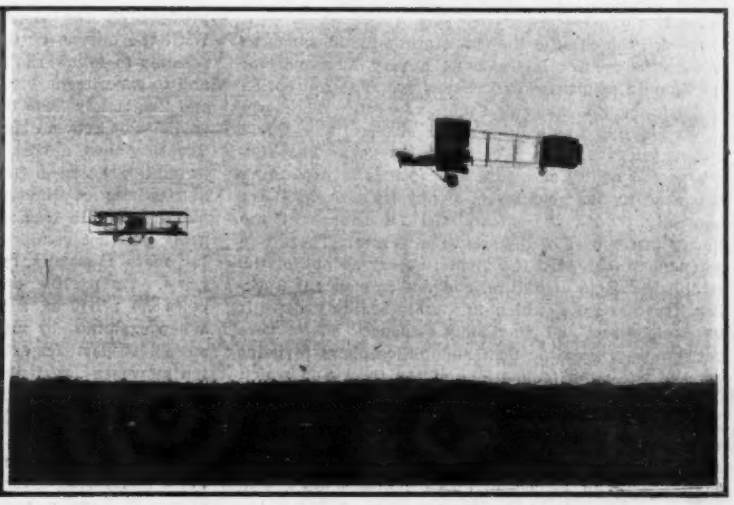
ANYTHING more unpropitious than the weather conditions under which the Rheims aviation meeting opened it would be difficult to imagine. During the previous night and early morning rain had been falling heavily, and on turning out of doors it was found that on the flagstaffs in the Place Royale and elsewhere black flags were displayed, intimating that flying was impossible. Enthusiasm was not so easily quenched. Many, heeding neither the weather nor the black flag, wended their way to the plains at Betheny. Matters looked less promising there. Mud was hardly the word to apply to the sticky, chalky substance which had formed itself into a veritable quagmire, ankle-deep in places, on the special "road" which had been made leading to the grand stand. At times some quaint scenes were witnessed in the effort to annex as little as possible of the Betheny soil. Some relief was later afforded by the laying down of planks over the more frequented points used by the public, so that it became possible to reach the inclosure without getting one's clothes absolutely ruined. Several of the motor cars, however, fared pretty badly, getting stuck in the soft mud, and having to be dragged out by horses. As things ultimately turned out, the crowds were rewarded for their optimism, for all in good time the weather cleared, and the programme as officially laid down was proceeded with, in spite of strong winds and heavy showers.

The first event was the French eliminating trials for the Gordon-Bennett race. For this there were twenty entries, and lots were drawn for starting order, each being allowed a quarter of an hour to get away. First out to the line was one of the red R. E. P. monoplanes, but this was unable to rise, and the first to actually make a start was Tissandier, on a Wright flyer, just before eleven o'clock. He only remained up for 1 minute, however, and was followed by Bleriot on one

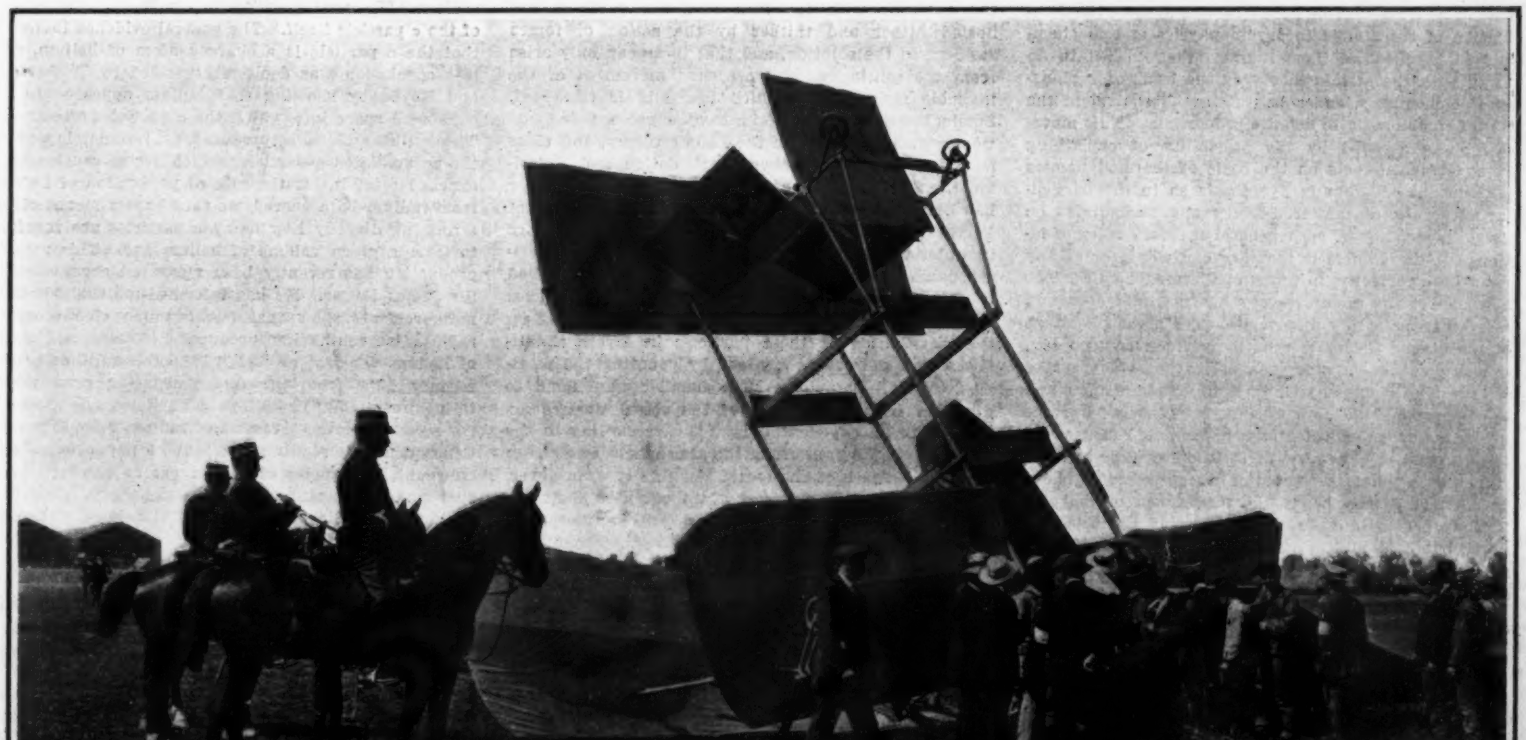
(Continued on page 180.)



HENRY FARMAN MAKING HIS ENDURANCE FLIGHT. TIME 3 HOURS, 4 MINUTES, 55⅘ SECONDS.



THE CURTISS AND VOISIN BIPLANES FLYING AT RIGHT ANGLES AND NARROWLY AVOIDING A COLLISION.



UNDER SIDE OF LOUIS BREGUET'S BIPLANE SHORTLY AFTER THE ACCIDENT.

This machine resembles the Farman, the chief differences being that the upper surfaces, both front and rear, are of greater spread than the lower ones and that there is a closed central body between the main planes. Note also the narrow horizontal surfaces between the rods that support the tail and the steadying wheels near the ends of the lower plane.

THE FIRST AVIATION MEETING AT RHEIMS, FRANCE.

VISUALIZING THE ATOM.*

HOW THE MODERN SCIENTIST COUNTS AND MEASURES ATOMS.

BY ERNEST RUTHERFORD.

It is my intention to discuss the present position of the atomic theory in physical science, and to review briefly the various methods that have been devised to determine the values of certain fundamental atomic magnitudes. The present time seems very opportune for this purpose, for the rapid advance of physics during the last decade has not only given us a much clearer conception of the relation between electricity and matter and of the constitution of the atom, but has provided us with experimental methods of attack undreamt of a few years ago. At a time when, in the vision of the physicist, the atmosphere is dim with flying fragments of atoms, it may not be out of place to see how it has fared with the atoms themselves, and to look carefully at the atomic foundations on which the great superstructure of modern science has been raised. Every physicist and chemist can not but be aware of the great part the atomic hypothesis plays in science to-day. The idea that matter consists of a great number of small discrete particles forms practically the basis of the explanation of all properties of matter.

Toward the close of the last century the ideas of the atomic theory had impregnated a very large part of the domain of physics and chemistry. The conception of atoms became more and more concrete. The atom in imagination was endowed with size and shape, and unconsciously in many cases with color. The simplicity and utility of atomic conceptions in explaining the most diverse phenomena of physics and chemistry naturally tended to enhance the importance of the theory in the eyes of the scientific worker. There was a tendency to regard the atomic theory as one of the established facts of nature, and not as a useful working hypothesis for which it was exceedingly difficult to obtain direct and convincing evidence. There were not wanting scientific men and philosophers to point out the uncertain foundations of the theory on which so much depended. Granting how useful molecular ideas were for the explanation of experimental facts, what evidence was there that the atoms were realities and not the figments of the imagination? It must be confessed that this lack of direct evidence did not in any way detract from the strength of the belief of the great majority of scientific men in the discreteness of matter. It was not unnatural, however, that there should be a reaction in some quarters against the domination of the atomic theory in physics and in chemistry. A school of thought arose that wished to do away with the atomic theory as the basis of explanation of chemistry, and substitute as its equivalent the law of combination in definite proportions. This movement was assisted by the possibility of explaining many chemical facts on the basis of thermodynamics without the aid of any hypothesis as to the particular structure of matter. Every one recognizes the great importance of such general methods of explanation, but the trouble is that few can think, or at any rate think correctly, in terms of thermodynamics. The negation of the atomic theory has not, and does not, help us to make new discoveries. The great advantage of the atomic theory is that it provides, so to speak, a tangible and concrete idea of matter which serves at once for the explanation of a multitude of facts and is of enormous aid as a working hypothesis. For the great majority of scientists it is not sufficient to group together a number of facts on general abstract principles. What is wanted is a concrete idea, however crude it may be, of the mechanism of the phenomena. This may be a weakness of the scientific mind, but it is one that deserves our sympathetic consideration. It represents an attitude of mind that appeals, I think, very strongly to the Anglo-Saxon temperament. It has no doubt as its basis the underlying idea that the facts of nature are ultimately explicable on general dynamical principles, and that there must consequently be some type of mechanism capable of accounting for the observed facts.

It has been generally considered that a decisive proof of the atomic structure of matter was in the nature of things impossible, and that the atomic theory must of necessity remain a hypothesis unverifiable by direct methods. Recent investigations have, however, disclosed such new and powerful methods of attack that we may well ask the question whether we do not now possess more decisive evidence of its truth.

Since molecules are invisible, it might appear, for example, an impossible hope that an experiment could be devised to show that the molecules of a fluid are in that state of continuous agitation which the kinetic theory leads us to suppose. In this connection I should like to draw your attention for a short time to a most striking phenomenon known as the "Brownian movement," which has been closely studied in recent years. Quite apart from its probable explanation the phenomenon is of unusual interest. In 1827 the English botanist Brown observed by means of a microscope that minute particles like spores of plants introduced into a fluid were always in a state of continuous irregular agitation, dancing to and fro in all directions at considerable speeds. For a long time this effect, known as the Brownian movement, was ascribed to inequalities in the temperature of the solution. This was disproved by a number of subsequent investigations, and especially by those of Gouy, who showed that the movement was spontaneous and continuous and was exhibited by very small particles of whatever kind when immersed in a fluid medium. The velocity of agitation increased with decrease of diameter of the particles and increased with temperature, and was dependent on the viscosity of the surrounding fluid. With the advent of the ultra-microscope it has been possible to follow the movements with more certainty and to experiment with much smaller particles. Exner and Zsigmondy have determined the mean velocity of particles of known diameter in various solutions, while Svedberg has devised an ingenious method of determining the mean free path and the average velocity of particles of different diameter. The experiments of Ehrenhaft in 1907 showed that the Brownian movement was not confined to liquids, but was exhibited far more markedly by small particles suspended in gases. By passing an arc discharge between silver poles he produced a fine dust of silver in the air. When examined by means of the ultra-microscope the suspended particles exhibited the characteristic Brownian movement, with the difference that the mean free path for particles of the same size was much greater in gases than in liquids.

The particles exhibit in general the character of the motion which the kinetic theory ascribes to the molecules themselves, although even the smallest particles examined have a mass which is undoubtedly very large compared with that of the molecule. The character of the Brownian movement irresistibly impresses the observer with the idea that the particles are hurled hither and thither by the action of forces resident in the solution, and that these can only arise from the continuous and ceaseless movement of the invisible molecules of which the fluid is composed. Smoluchowski and Einstein have suggested explanations which are based on the kinetic theory, and there is a fair agreement between calculation and experiment. Strong additional confirmation of this view has been supplied by the very recent experiments of Perrin (1909). He obtained an emulsion of gamboge in water which consisted of a great number of spherical particles nearly of the same size, which showed the characteristic Brownian movement. The particles settled under gravity and when equilibrium was set up the distribution of these particles in layers at different heights was determined by counting the particles with a microscope. The number was found to diminish from the bottom of the vessel upward according to an exponential law, i. e., according to the same law as the pressure of the atmosphere diminishes from the surface of the earth. In this case, however, on account of the great mass of the particles, their distribution was confined to a region only a fraction of a millimeter deep. In a particular experiment the number of particles per unit volume decreased to half in a distance of 0.038 millimeter, while the corresponding distance in our atmosphere is about 6,000 meters. From measurements of the diameter and weight of each particle, Perrin found that, within the limit of experimental error, the law of distribution with height indicated that each small particle had the same average kinetic energy of movement as the molecules of the solutions in which they were suspended; in fact, the particles in suspension behaved in all respects like molecules of very high molecular weight. This is a very important result, for it indicates that the law of equipartition of energy among molecules of different masses, which is an important deduction from the kinetic theory, holds, at any rate very approximately, for a distribution of particles in a medium whose masses and dimensions are exceedingly large compared with that of the molecules of the medium. Whatever may prove to be the exact explanation of this phenomenon, there can be little doubt that it results from the movement of the molecules of the solution and is thus a striking if somewhat indirect proof of the general correctness of the kinetic theory of matter.

From recent work in radio-activity we may take a second illustration which is novel and far more direct. It is well known that the α rays of radium are deflected by both magnetic and electric fields. It may be concluded from this evidence that the radiation is corpuscular in character, consisting of a stream of positively charged particles projected from the radium at a very high velocity. From the measurements of the deflection of the rays in passing through magnetic and electric fields the ratio e/m of the charge carried by the particle to its mass has been determined, and the magnitude of this quantity indicates that the particle is of atomic dimensions.

Rutherford and Geiger have recently developed a direct method of showing that this radiation is, as the other evidence indicated, discontinuous, and that it is possible to detect by a special electric method the passage of a single α particle into a suitable detecting vessel. The entrance of an α particle through a small opening was marked by a sudden movement of the needle of the electrometer which was used as a measuring instrument. In this way, by counting the number of separate impulses communicated to the electrometer needle, it was possible to determine by direct counting the number of α particles expelled per second from one gramme of radium. But we can go further and confirm the result by counting the number of α particles by an entirely distinct method. Sir William Crookes has shown that when the α rays are allowed to fall upon a screen of phosphorescent zinc sulphide, a number of brilliant scintillations are observed. It appears as if the impact of each α particle produced a visible flash of light where it struck the screen. Using suitable screens the number of scintillations per second on a given area can be counted by means of a microscope. It has been shown that the number of scintillations determined in this way is equal to the number of impinging α particles when counted by the electric method. This shows that the impact of each α particle on the zinc sulphide produces a visible scintillation. There are thus two distinct methods—one electrical, the other optical—for detecting the emission of a single α particle from radium. The next question to consider is the nature of the α particle itself. The general evidence indicates that the α particle is a charged atom of helium, and this conclusion was decisively verified by Rutherford and Royds by showing that helium appeared in an exhausted space into which the α particles were fired. The helium, which is produced by radium, is due to the accumulated α particles which are so continuously expelled from it. If the rate of production of helium from radium is measured, we thus have a means of determining directly how many α particles are required to form a given volume of helium gas. This rate of production has recently been measured accurately by Sir James Dewar. He has informed me that his final measurements show that one gramme of radium in radio-active equilibrium produces 0.46 cubic millimeter of helium per day, or 5.32×10^{-6} cubic millimeter per second. Now from the direct counting experiments it is known that 13.6×10^{10} α particles are shot out per second from one gramme of radium in equilibrium. Consequently it requires 2.56×10^{19} α particles to form one cubic centimeter of helium gas at standard pressure and temperature.

From other lines of evidence it is known that all the α particles from whatever source are identical in mass and constitution. It is not then unreasonable to suppose that the α particle, which exists as a separate entity in its flight, can exist also as a separate entity when the α particles are collected together to form a measurable volume of helium gas, or, in other words, that the α particle on losing its charge becomes the fundamental unit or atom of helium. In the case of a monatomic gas like helium, where the atom and molecule are believed to be identical, no difficulty of deduction arises from the possible combination of two or more atoms to form a complex molecule.

We consequently conclude from these experiments that one cubic centimeter of helium at standard pressure and temperature contains 2.56×10^{19} atoms. Knowing the density of helium, it at once follows that each atom of helium has a mass of 6.8×10^{-24} gramme, and that the average distance apart of the molecules in the gaseous state at standard pressure and temperature is 3.4×10^{-7} centimeter.

The above result can be confirmed in a different way.

* Abstracted from a paper read before the British Association for the Advancement of Science.

it is known that the value of e/m for the α particle is 5,070 electromagnetic units. The positive charge carried by each α particle has been deduced by measuring the total charge carried by a counted number of α particles. Its value is 9.3×10^{-10} electrostatic unit, or 3.1×10^{-20} electromagnetic unit. Substituting this number in the value of e/m, it is seen that m, the mass of the α particle, is equal to 6.1×10^{-24} gramme—a value in fair agreement with the number previously given.

I trust that my judgment is not prejudiced by the fact that I have taken some share in these investigations; but the experiments, taken as a whole, appear to me to give an almost direct and convincing proof of the atomic hypothesis of matter. By direct counting, the number of identical entities required to form a known volume of gas has been measured. May we not conclude that the gas is discrete in structure, and that this number represents the actual number of atoms in the gas?

We have seen that under special conditions it is possible to detect easily by an electrical method the emission of a single α particle; i. e., of a single charged atom of matter. This has been rendered possible by the great velocity and energy of the expelled α particle, which confers on it the power of dissociating or ionizing the gas through which it passes. It is obviously only possible to detect the presence of a single atom of matter when it is endowed with some special property or properties which distinguishes it from the molecules of the gas with which it is surrounded. There is a very important and striking method, for example, of visibly differentiating between the ordinary molecules of a gas and the ions produced in the gas by various agencies. C. T. R. Wilson showed in 1897 that under certain conditions each charged ion became a center of condensation of water vapor, so that the presence of each ion was rendered visible to the eye. Sir Joseph Thomson, H. A. Wilson, and others have employed this method to count the number of ions present and to determine the magnitude of the electric charge carried by each.

A few examples will now be given which illustrate the older methods of estimating the mass and dimensions of molecules. As soon as the idea of the discrete structure of matter had taken firm hold, it was natural that attempts should be made to estimate the degree of coarse-grainedness of matter, and to form an idea of the dimension of molecules, assuming that they have extension in space. Lord Rayleigh has drawn attention to the fact that the earliest estimate of this kind was made by Thomas Young in 1805, from considerations of the theory of capillarity. Space does not allow me to consider the great variety of methods that have later been employed to form an idea of the thickness of a film of matter in which a molecular structure is discernible. This phase of the subject was always a favorite one with Lord Kelvin, who developed a number of important methods of estimating the probable dimensions of molecular structure.

The development of the kinetic theory of gases on a mathematical basis at once suggested methods of estimating the number of molecules in a cubic centimeter of any gas at normal pressure and temperature. This number, which will throughout be denoted by the symbol N, is a fundamental constant of gases; for, according to the hypothesis of Avogadro, and also on the kinetic theory, all gases at normal pressure and temperature have an identical number of molecules in unit volume. Knowing the value of N, approximate estimates can be made of the diameter of the molecule; but in our ignorance of the constitution of the molecule, the meaning of the term diameter is somewhat indefinite. It is usually considered to refer to the diameter of the sphere of action of the forces surrounding the molecule. This diameter is not necessarily the same for the molecules of all gases, so that it is preferable to consider the magnitude of the fundamental constant N. The earliest estimates based on the kinetic theory were made by Loschmidt, Johnstone Stoney, and Maxwell. From the data then at his disposal, the latter found N to be 1.9×10^{19}. Meyer, in his "Kinetic Theory of Gases," discusses the various methods of estimating the dimensions of molecules on the theory, and concludes that the most probable estimate of N is 6.1×10^{19}. Estimates of N based on the kinetic theory are only approximate, and in many cases serve merely to fix an inferior or superior limit to the number of the molecules. Such estimates are, however, of considerable interest and historical importance, since for a long time they served as the most reliable methods of forming an idea of molecular magnitudes.

A very interesting and impressive method of determining the value of N was given by Lord Rayleigh in 1899 as a deduction from his theory of the blue color in the cloudless sky. The theory supposes that the molecules of the air scatter the waves of light incident upon them. This scattering for particles, small compared with the wave-length of light, is proportional to the fourth power of the wave-length, so that the proportion of scattered to incident light is much greater for the violet than for the red end of the spectrum, and consequently the sky which is viewed by the scattered light is of a deep blue color. This scattering of the light in passing through the atmosphere causes alterations of brightness of stars when viewed at different altitudes, and determinations of this loss of brightness have been made experimentally.

Knowing this value, the number N of molecules in unit volume can be deduced by aid of the theory. From the data thus available, Lord Rayleigh concluded that the value of N was not less than 7×10^{19}. Lord Kelvin in 1902 recalculated the value of N on the theory by using more recent and more accurate data, and found it to be 2.47×10^{19}. Since in the simple theory no account is taken of the additional scattering due to fine suspended particles which are undoubtedly present in the atmosphere, this method only serves to fix an inferior limit to the value of N. It is difficult to estimate with accuracy the correction to be applied for this effect, but it will be seen that the uncorrected number deduced by Lord Kelvin is not much smaller than the most probable value 2.77×10^{19} given later. Assuming the correctness of the theory and data employed, this would indicate that the scattering due to suspended particles in the atmosphere is only a small portion of the total scattering due to molecules of air. This is an interesting example of how an accurate knowledge of the value of N may possibly assist in forming an estimate of unknown magnitudes.

It is now necessary to consider some of the more recent and direct methods of estimating N which are based on recent additions to our scientific knowledge. The newer methods allow us to fix the value of N with much more certainty and precision than was possible a few years ago.

We have referred earlier in the paper to the investigations of Perrin on the law of distribution in a fluid of a great number of minute granules, and his proof that the granules behave like molecules of high molecular weight. The value of N can be deduced at once from the experimental results, and is found to be 3.14×10^{19}. The method developed by Perrin is a very novel and ingenious one, and is of great importance in throwing light on the law of equipartition of energy. This new method of attack of fundamental problems will no doubt be much further developed in the future.

It has already been shown that the value $N = 2.56 \times 10^{19}$ has been obtained by the direct method of counting the α particles and determining the corresponding volume of helium produced. Another very simple method of determining N from radioactive data is based on the rate of transformation of radium. Boltwood has shown by direct experiment that radium is half transformed in 2,000 years. From this it follows that initially in a gramme of radium 0.346 milligramme breaks up per year. Now it is known from the counting method that 3.4×10^{10} α particles are expelled per second from one gramme of radium, and the evidence indicates that one α particle accompanies the disintegration of each atom. Consequently the number of α particles expelled per year is a measure of the number of atoms of radium present in 0.346 milligramme. From this it follows that there are 3.1×10^{21} atoms in one gramme of radium, and taking the atomic weight of radium as 226, it is simply deduced that the value of N is 3.1×10^{19}.

(To be continued.)

COMPENSATION BETWEEN THE CHARACTER OF THE SEASONS IN DIFFERENT PARTS OF THE WORLD.

SEVERAL attempts have been made to discover evidence of the interdependence of the seasons in different parts of the world. Guided by the supposition that the temperature of the polar seas has an important influence in the world's weather, H. H. Hildebrandsson brings forward evidence for the following: (1) The summer temperature near the North Cape is "opposed" to that of the following spring in Iceland. (2) The polar current which reaches Iceland in March enters Baffin Bay only in the following winter, and thus the air temperature at Gothaab (west coast, Greenland) in spring has a similar divergence from normal to that at Grimsey (North Iceland) in March of the preceding year. (3) The cold water leaving Baffin Bay in winter reaches the banks of Newfoundland in the following summer. The winter air temperature at Upernavik (Baffin Bay) is inverse to that of the following July at St. John's. The temperature at St. John's in July is highest in those years which have the greatest amount of ice in the Atlantic. As explanation of this apparently contradictory result, it is suggested that the low water temperature gives rise to anticyclonic conditions, and this pressure distribution favors the development of high temperatures over the land in summer. (4) The branch of the polar current which at the end of winter passes to the northeast of Iceland continues its course toward the southeast to Thorshavn (Faroe) and into the North Sea, and brings with it a more or less low temperature and consequently high pressure. This is the cause of the high pressure which generally prevails over this region in spring. This distribution brings cold northerly winds to Europe, which extend even into Hungary. The divergence of the pressure in spring at Thorshavn is always opposed to the divergence of the simultaneous temperature at Debreczin in Hungary. The Siberian temperature is also found to be the inverse of that over Europe. (5) In autumn a similar opposition prevails between the divergence of the temperature at Thorshavn and Barnaul (Siberia). (6) During winter (October-March) the curves for precipitation for Thorshavn and Barnaul are opposed to one another, but the variations at Thorshavn and Zi-ka-wei (Shanghai) are almost identical. (7) In winter there is also opposition between the precipitation over the Iceland sea and over Central Europe, Southern France, and even over the Azores. (8) The curve of winter rain for Java is almost identical with that for pressure during the following summer at Bombay.

BEGINNINGS OF MODERN MEDICINE.

"THE Beginnings of Modern Medicine" was the subject of a lecture delivered recently to a large gathering of University Extension students at Oxford by Dr. W. Osler, the regius professor of medicine. In opening his address he quoted the words of Sir Henry Maine that "to one small people it was given to create the principle of progress; that people was the Greek. Except the blind forces of nature, nothing moves in this world which is not Greek in its origin." Those words were as true of medicine as of philosophy and science. To the work of the Hippocratic physicians of ancient Greece they owed, first, the emancipation of medicine from the shackles of priestcraft and of caste; secondly, the conception of medicine as an art based on accurate observation and as a science—an integral part of the science of man and of nature; thirdly, the high moral ideals expressed in that most "memorable of human documents" (Gomperz), the Hippocratic oath; and, fourthly, the conception and realization of medicine as the profession of a cultivated gentleman.

Dr. Osler pointed out that, in spite of the great change effected by the Renaissance, men still clung to the old Hippocratic views of the four humors and the three spirits—natural, animal, and vital—and the conception of the working of the bodily machine had undergone little or no change. The end of the sixteenth century still saw the dominance of the views of the great Pergamite, and, in spite of all the good work which had been done in anatomy, that which seemed to them to-day so simple—the circulation of the blood—was as little understood as in the days of Galen. It was reserved for the immortal Harvey, whose name was connected with Oxford, as for a time he was warden of Merton College, to put into practice the experimental methods with which he demonstrated conclusively that the blood moved in a circle. The little book "De Motu Cordis" marked the final break of the modern spirit with the old traditions.

It took a long time before men realized the value of this *inventum mirabile*, sought for so earnestly by Descartes. Indeed, they had only done so within the past century. With a glorious beginning at a glorious period in the world's history, the profession of medicine retained the noble attributes which inspired their Greek fathers. But not the keen vision of Hippocrates as he discussed with Plato the oneness with nature and the naturalness of all disease; not the philosophic insight of Galen at its brightest moment, stimulated by converse with his friend Marcus Aurelius; not the mystic yearning of the Persian physician-poet Avicenna amid his guests "star-seated on the grass," could have given these men the faintest conception of the possibility of such progress as the Victorian era had witnessed. Great as had been their achievements in literature, yet greater in the physical sciences, and greater still in social and political reforms, they were as nothing in respect to the gifts which modern medicine had given to suffering humanity—the conquest of pain, Listerian surgery, and the control of infectious diseases. And the end was not yet; but the present was a worthy outcome of the beginnings of which they had taken this brief and hurried glance.

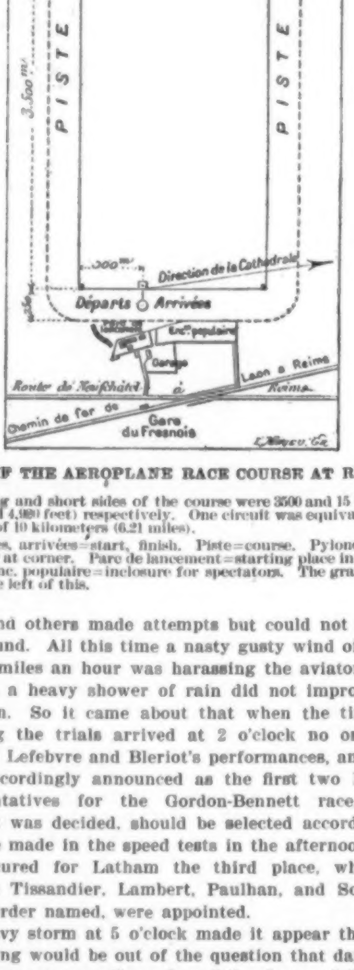
In the SCIENTIFIC AMERICAN SUPPLEMENT, No. 1755, there was published on page 127 a calendar said to be good for 200 years. A subscriber informs us that from this calendar it appears that the 1st of February and the 1st of November always fall on the same week day for the same year. In leap years, however, this is not the case. According to the calendar the 1st of February and the 1st of November, 1908, fell on a Saturday, whereas the 1st of February really fell on a Saturday and the 1st of November on a Sunday.

THE RHEIMS AVIATION MEETING.

DETAILS OF THE FIRST GREAT EXHIBITION OF DYNAMIC FLIGHT.

Continued from Front Page.

of the little cross-Channel monoplanes. He managed to cover about 2½ kilometers, and then Latham had a try. His machine bore the number 13, and to this was attributed his failure to keep going for more than about 500 yards. Lefebvre's turn came next, and he made the best attempt, very nearly completing two laps of the 10-kilometer course. Capt. Ferber (de



PLAN OF THE AEROPLANE RACE COURSE AT RHEIMS.

The long and short sides of the course were 3500 and 15 0 meters (11,480 and 4,920 feet) respectively. One circuit was equivalent to a distance of 10 kilometers (6.21 miles).

Départes, arrivées=start, finish. Piste=course. Pylone=marking tower at corner. Parc de lancement=starting place in front of sheds. Enc. populaire=inclosure for spectators. The grand stand was at the left of this.

Rue) and others made attempts but could not get off the ground. All this time a nasty gusty wind of about twenty miles an hour was harassing the aviators, and at noon a heavy shower of rain did not improve the situation. So it came about that when the time for finishing the trials arrived at 2 o'clock no one had bettered Lefebvre and Bleriot's performances, and they were accordingly announced as the first two French representatives for the Gordon-Bennett race. The third, it was decided, should be selected according to the pace made in the speed tests in the afternoon, and this secured for Latham the third place, while as reserves Tissandier, Lambert, Paulhan, and Sommer, in the order named, were appointed.

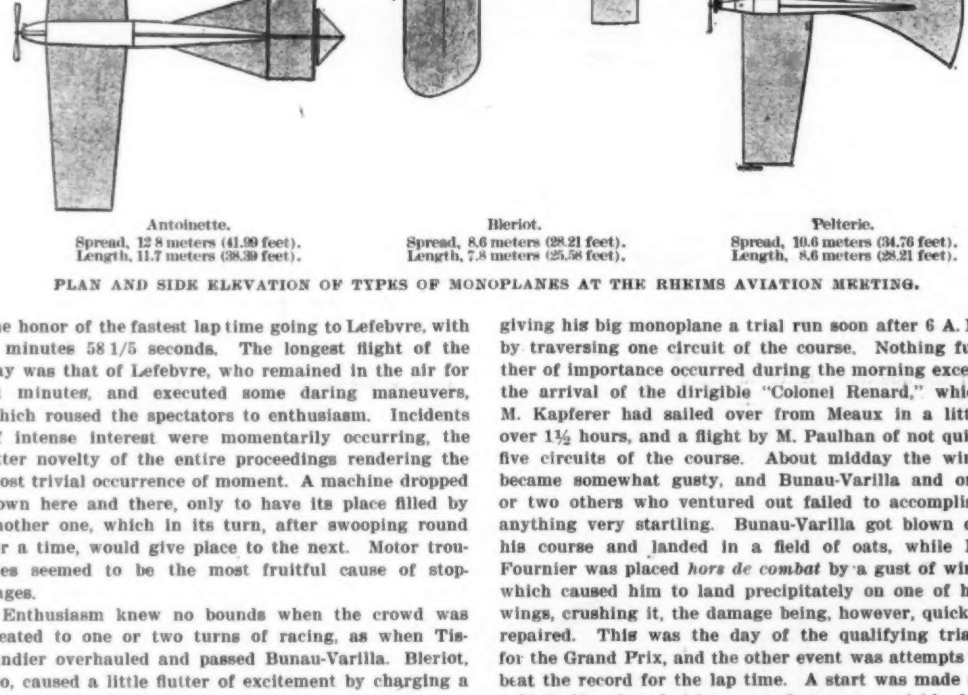
A heavy storm at 5 o'clock made it appear that further flying would be out of the question that day. But quick changes were the order of the day, and half an hour later the weather broke, and immediately all was animation among the aviators, who proceeded to bring out their machines for the speed trials. Latham was the first away, he being rapidly followed by others, until the wonderful and unprecedented spectacle was witnessed of seven machines in the air at one time. Five, including Tissandier, Lambert, Lefebvre, Paulhan and Sommer, succeeded in covering the 30 kilometers for the speed prizes, the three Wright machines and their pilots doing justice to their master by securing the three first places. Moreover, it was vastly interesting to note that the difference between Tissandier, who was first, and Lefebvre and Lambert, who were bracketed second, was only 1 3/5 seconds. In addition to the above, Latham, on his "Antoinette," twice made a single circuit, and Cockburn, on his Farman, once, the honor of the fastest lap time going to Lefebvre, with 8 minutes 58 1/5 seconds. The longest flight of the day was that of Lefebvre, who remained in the air for 41 minutes, and executed some daring maneuvers, which roused the spectators to enthusiasm. Incidents of intense interest were momentarily occurring, the utter novelty of the entire proceedings rendering the most trivial occurrence of moment. A machine dropped down here and there, only to have its place filled by another one, which in its turn, after swooping round for a time, would give place to the next. Motor troubles seemed to be the most fruitful cause of stoppages.

Enthusiasm knew no bounds when the crowd was treated to one or two turns of racing, as when Tissandier overhauled and passed Bunau-Varilla. Bleriot, too, caused a little flutter of excitement by charging a stack of wheat sheaves, resulting in a damaged propeller. Altogether the total distance covered in their flights by the various "bird-men" during the day amounted to 309 kilometers (192 miles).

Among the spectators were the Right Hon. Lloyd George and Sir Henry Norman, who had motored from Boulogne, stopping the previous night at Compiegne. The Chancellor of the Exchequer was intensely impressed, and did not hesitate to express a wish that such a meeting could be held on Salisbury Plain or some other convenient spot in the British Isles. It is to be hoped that he will be able to impart some of his enthusiasm to other members of the Cabinet, so that aviation may receive a little more encouragement in Great Britain. Sir Henry Norman, who was equally impressed, gave vent to his feelings by expressing the opinion that the world was that day witnessing the birth of a new epoch of human development.

MONDAY'S EVENTS.

What a contrast to the opening morning was the second day's dawn! On the Monday morning all was fair and calm, and to all appearance weather after the aviators' heart was in store. Bleriot was up betimes giving his big monoplane a trial run soon after 6 A. M. by traversing one circuit of the course. Nothing further of importance occurred during the morning except the arrival of the dirigible "Colonel Renard," which M. Kapferer had sailed over from Meaux in a little over 1½ hours, and a flight by M. Paulhan of not quite five circuits of the course. About midday the wind became somewhat gusty, and Bunau-Varilla and one or two others who ventured out failed to accomplish anything very startling. Bunau-Varilla got blown off his course and landed in a field of oats, while M. Fournier was placed *hors de combat* by a gust of wind which caused him to land precipitately on one of his wings, crushing it, the damage being, however, quickly repaired. This was the day of the qualifying trials for the Grand Prix, and the other event was attempts to beat the record for the lap time. A start was made at 4:30 P. M., when Lefebvre was first away, quickly followed by Paulhan. Lefebvre covered 21.2 kilometers (13.2 miles) in 20 min. 14 2/5 secs., when he decided to come down, while Paulhan kept going until 56 kilometers had been covered in 58 mins. 48 4/5 secs. Several of the competitors also attacked the circuit record, and Bleriot succeeded in reducing it to 8 mins. 42 2/5 secs., but his victory was short-lived, as Curtiss later, in his American biplane, brought it down to 8 mins. 35 3/5 secs. One condition of the Grand Prix was that competitors had to fly a reasonable distance on or be-

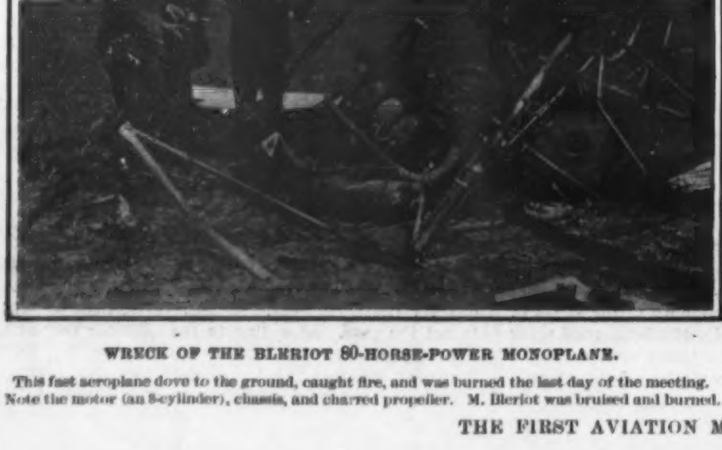


Antoinette. Spread, 12.8 meters (41.99 feet). Length, 11.7 meters (38.39 feet).

Bleriot. Spread, 8.6 meters (28.21 feet). Length, 7.8 meters (25.58 feet).

Pelterie. Spread, 10.6 meters (34.76 feet). Length, 8.6 meters (28.21 feet).

PLAN AND SIDE ELEVATION OF TYPES OF MONOPLANES AT THE RHEIMS AVIATION MEETING.



WRECK OF THE BLERIOT 80-HORSE-POWER MONOPLANE.

This fast aeroplane dove to the ground, caught fire, and was burned the last day of the meeting. Note the motor (an 8-cylinder), chassis, and charred propeller. M. Bleriot was bruised and burned.

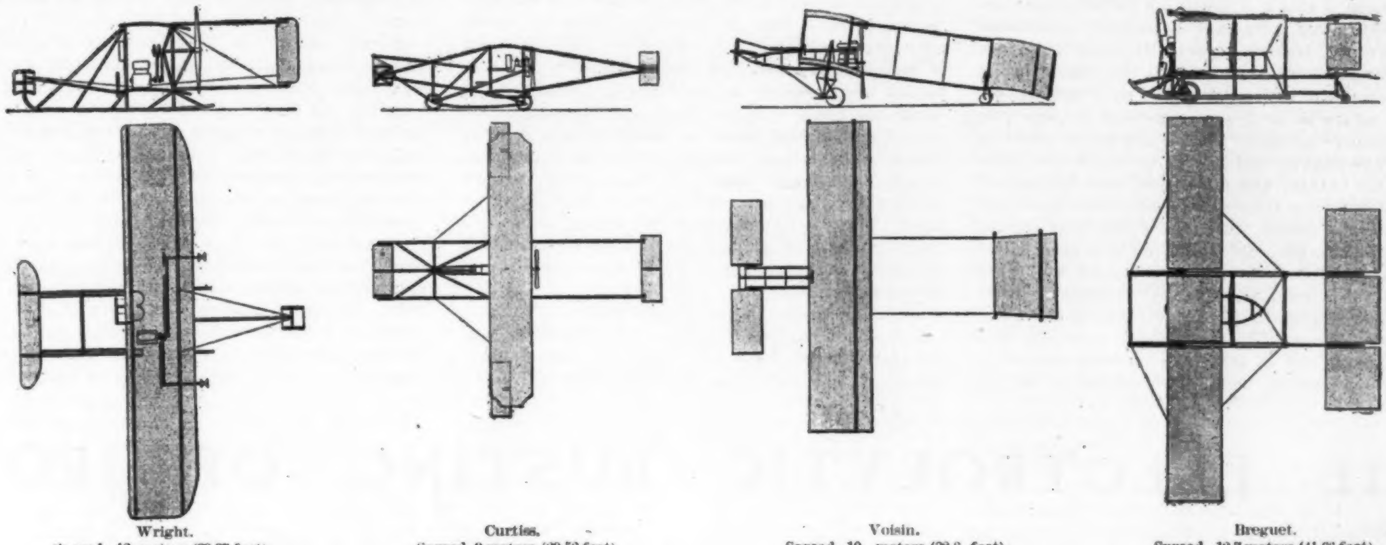
THE BREGUET BIPLANE JUST AS IT STRUCK THE GROUND.

After making a few short flights this machine dove head on to earth the last day of the meeting. M. Breguet escaped miraculously without serious injuries.

THE FIRST AVIATION MEETING AT RHEIMS, FRANCE.

fore Monday to qualify to take part in the trials on Wednesday, Thursday, and Friday. Under this regulation eighteen actually qualified.

Before the close of the day's proceedings Lefebvre again provided the crowd with a series of thrills by Channel rival, demonstrated that he had easily the faster machine. Enthusiasm was intense when it was found that he had handsomely beaten the record, bringing it down to 8 minutes 4 2/5 seconds. Lefebvre was again flying in the dusk, and once more performed least as gay as it could be in face of a heavy downpour of rain. Next morning the black clouds presaged anything but the best weather conditions. However, the wind was very light, and as on several occasions more than one aviator has shown an indifference



Wright. Spread, 12 meters (39.37 feet). Length, 8.5 meters (27.88 feet).

Curtiss. Spread, 9 meters (29.52 feet). 60-horse-power, 8-cylinder motor.

Voisin. Spread, 10 meters (32.8 feet). Length, 11.5 meters (37.72 feet).

Breguet. Spread, 12.7 meters (41.66 feet). Length, 8 meters (26.24 feet).

PLAN AND SIDE ELEVATION OF TYPES OF BIPLANES AT THE RHEIMS AVIATION MEETING.

flying over and under and circling round Paulhan, who was at a height of about 25 feet. Arising out of this, when making one of his dashes under his rival's machine, he swooped down so suddenly and so close to *terra firma* that one of the vast brigade of press photographers who swarmed over the flying ground, and in whose direction Lefebvre was traveling in a bee line, in not unnatural terror flung himself flat on the ground, not realizing what was happening, and fearing that his last moment had suddenly arrived. A couple of seconds relieved his anxiety, but a brother "photo fiend" had recorded the incident in the meantime.

TUESDAY'S PROGRESS.

Black flags had once more to be hoisted on Tuesday morning, the strong winds blowing rendering flying out of the question. Later on angry and ominous clouds gathered over the ground, and it looked as though a wet reception awaited M. le President, for this was the day he had chosen for his first visit. Just before 4 o'clock, when President Fallières arrived, however, the weather improved somewhat, but flying was still impossible, so the President spent some time examining the various machines, and receiving their various designers and pilots. He also received the British deputation, headed by Gen. French, and just before 5 took his seat in the grand stand.

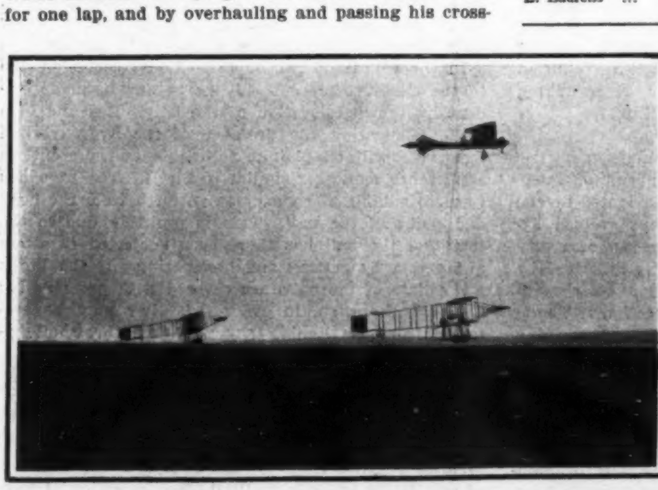
The starting of engines notified that flying was to be attempted, and in a few minutes Bunau-Varilla swept past the grand stand, waving his hat to the distinguished occupants. He, however, only remained up for a few minutes, when his place was taken by Paulhan, who managed to just complete his second lap as the Presidential party started back for the railway station. Altogether he completed three laps, but his time was a good way off the record, which was hardly surprising in view of the strong wind against which he had to contend. The only other aviator to make the three rounds was Latham, whose time was 30 minutes 2 seconds, but the time officially recorded against him was 5 per cent more than that—31 minutes 32 1/5 seconds. This "fine" was under the penalization rule for his unfinished attempt on Sunday. While Latham was flying, Bleriot took a turn around for one lap, and by overhauling and passing his cross-some extraordinary evolutions, the most impressive being a number of sharp double turns and "8's" in front of the grand stand.

WEDNESDAY'S RACING.

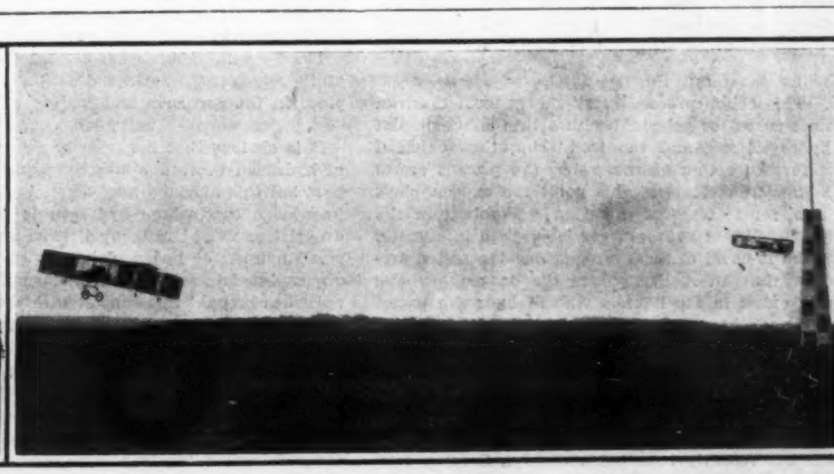
On Tuesday night Rheims had been *en fete*, or at to rain, it was vainly hoped that some one would venture into the central blue. Until nearly 4 o'clock, when Paulhan started off on a trial for the Grand Prix, and, as it turned out, made a wonderful performance by shifting the world's record for duration and dis-

TABLE OF GENERAL DETAILS OF THE ENTERED MACHINES (APPROXIMATE FIGURES).

Pilots.	Make of Flyer.	Supporting Surface.	Weight, Flying Order.	Stability.	Chassis.	Engine. Motor and H. P.	Engine. Cooling.	Engine. Ignition.	Propellers. Make.	Propellers. Blades.	Propellers. Diameter.	Propellers. R. P. M.
BIPLANES.												
		sq.m.	kgs.			h.p.					m.	
P. Tissandier	Wright	50	470	Warping	Runners	25 4-cyl. B. and M.	Water	H.T. mag.	2 Wright	2	2·5	450
"	"	50	470	"	"	" "	"	"	"	2	2·5	450
Comte de Lambert	"	50	470	"	"	" "	"	"	"	2	2·5	450
"	"	50	470	"	"	" "	"	"	"	2	2·5	450
Schreck	"	50	470	"	"	" "	"	"	"	2	2·5	450
E. Lefebvre	Ariel Co.	40	450	"	"	" "	"	"	"	2	2·5	450
——	"	40	450	"	"	" "	"	"	"	2	2·5	450
H. Farman	Farman	40	560	Ailerons (tips)	Runners and wheels	50 4-cyl. Vivinus	"	"	1 Chauviere	2	2·6	1,200
"	"	40	560	"	"	" "	"	"	"	2	2·6	1,200
R. Sommer	"	40	560	"	"	50 5-cyl. Gnome	Air	"	"	2	2·6	1,100
G. B. Cockburn	"	40	560	"	"	" "	"	"	"	2	2·6	1,100
J. Gobron	Voisin	50	560	Automatic	Wheels	55 4-cyl. Gobron	Water	2 mag.	1 Voisin	2	2·0	1,150
Delagrange	"	50	560	"	"	50 8-cyl. Antoinette	"	Accu.	"	2	2·0	1,100
De Rue (Capt. Ferber)	"	50	560	"	"	" "	"	"	"	2	2·0	1,1C0
Paulhan	"	50	560	"	"	50 5-cyl. Gnome	Air	Mag.	"	2	2·0	1,200
Bunau-Varilla	"	50	560	"	"	50 8-cyl. E.N.V.	Water	"	"	2	2·0	1,200
Rougier	"	50	560	"	"	55 8-cyl. Renault	Air	"	"	2	2·0	1,200
Fournier	"	50	560	"	"	50 4-cyl. Itala	Water	"	"	2	2·0	1,100
Sanchez Besa	"	50	560	"	"	50 8-cyl. Antoinette	"	Accu.	"	2	2·0	1,100
Legagneux	"	50	560	"	"	55 4-cyl. Gobron	"	2 mag.	"	2	2·0	1,150
Glenn Curtiss	Curtiss	24	320	Ailerons (tips)	"	30 3-cyl. Curtiss	Air	Accu.	1 Curtiss	2	1·8	1,300
Breguet	Breguet	50	640	Warping	"	55 8-cyl. Renault	"	Mag.	1 Breguet	3	2·5	1,200
Klutymans	Klutymans	—	—	—	—		—	—	—	—	—	—
Fernandez	Fernandez	50	480	Warping	Wheels	50 8-cyl. Antoinette	Water	Accu.	1 Chauviere	2	3·0	1,100
MONOPLANES.												
L. Bleriot	Bleriot	22	550	Ailerons (tips)	Wheels	40 3-cyl. Anzani	Air	Accu.	1 Chauviere	2	2·7	500
"	"	22	620	"	"	50 8-cyl. E.N.V.	Water	H.T. mag.	"	2	2·7	500
"	"	14	340	Warping	"	25 3-cyl. Anzani	Air	Accu.	"	2	2·08	1,400
L. Delagrange	"	14	340	"	"	" "	"	"	"	2	2·08	1,400
H. Latham	Antoinette	50	520	Ailerons (tips)	Runners and wheels	50 8-cyl. Antoinette	Water	"	1 Antoinette	2	2·20	1,100
Demanest	"	50	920	"	"	" "	"	"	"	2	2·20	1,100
Buchonnet	"	42	490	"	"	" "	"	"	"	2	2·20	1,100
Bailly	"	50	520	Warping	"	" "	"	"	"	2	2·20	1,100
R. Esnault-Pelterie	R.E.P.	20	450	"	Wheels	35 7-cyl. R.E.P.	Air	H.T. mag.	1 R.E.P.	4	2·0	1,400
"	"	20	450	"	"	" "	"	"	"	4	2·0	1,400
M. Guffroy	"	20	450	"	"	" "	"	"	"	4	2·0	1,400
E. Laurens	"	20	450	"	"	" "	"	"	"	4	2·0	1,400



THE ANTOINETTE MONOPLANE AND TWO FARMAN BIPLANES RACING FOR THE GRAND PRIX DE LA CHAMPAGNE.



TWO OF THE VOISIN BIPLANES MAKING A TURN.

THE FIRST AVIATION MEETING AT RHEIMS, FRANCE.

tance a good way further on, there was nothing of moment to vary the monotony of waiting to record. He did not come down till after half-past 6, when he had been up 2 hours 43 minutes 24 4/5 seconds, and had traversed 131 kilometers (82 miles). This is over 6 minutes ahead of Sommer's recently-made unofficial record, and more than 23 minutes better than Wilbur Wright's previous record. Naturally, of course, this performance overshadowed all the others during the afternoon, and the scenes around the young aviator upon his return to earth were somewhat disconcerting to his dignity—at least, from a Britisher's point of view. While Paulhan had been pursuing the even tenor of his way, Latham and others had been making attempts to better the circuit times, and Fournier experienced a second tumble, this time much more serious than the first smash. He was flying at a good height and had traveled about half-way around the track, when his Voisin machine, struck by a miniature whirlwind, suddenly swerved, turned over once or twice, and then crashed sideways to the ground. Fournier, with the usual good luck of an aviator, escaped serious injury, and returned to his shed riding the horse of a friendly gendarme. His machine was badly broken up, the tail being severed from the main body. Latham, on his third attempt, succeeded in covering the 30 kilometers, his time, however, being slower than the record for the Prix de Vitesse. While he was in the air a splendid rainbow appeared in the sky, and the spectacular effect of this, in conjunction with the Antoinette dragon-fly, was most impressive and not likely to be soon forgotten by those who were fortunate enough to witness it. In the twilight Curtiss tried to regain the honor of fastest time, and although he improved on his former speed, he could not lower Bleriot's record, while several aviators, including Delagrange, Rougier and Capt. Ferber (de Rue), were out, but nothing startling, in view of previous exploits, transpired. Truly is it that familiarity breeds, if not contempt, in this case, at least indifference, and that very speedily. The marvelous of to-day is but the accepted of to-morrow.

RECORDS BROKEN ON THURSDAY.

A splendid day was experienced on Thursday, and the sensation was Latham's world's distance record of 152 kilometers (96 miles), his speed also beating all previous efforts, thereby bringing about the curious anomaly of not breaking the duration record. His time for the 150 kilometers was 2 hours, 13 minutes, 9 3/5 seconds. This splendid effort was made during the afternoon, and followed a preliminary canter of 70 kilometers, which he flew during the morning in 1 hour, 1 minute, 51 2/5 seconds.

In each case he was forced to come down owing to his petrol supply giving out, but his second marvelous flight easily placed him first for the Grand Prix.

During the long flight there were several exciting incidents. On one occasion Mr. Latham had the opportunity of racing with a passing train for some distance, while at another time he passed over Delagrange, who was flying around the course on his Bleriot.

Another thrill was afforded by Bleriot who carried a passenger during a couple of flights, while Curtiss completed four circuits of the course, and Mr. Cockburn also indulged in a race with another train.

For the above graphic description of the Rheims meeting, we are indebted to the English weekly Flight. For the happenings of the last three days, we refer our readers to the SCIENTIFIC AMERICAN of September 11th.

THE ELECTROLYTIC RUSTING OF IRON.

AN EXPERIMENT ILLUSTRATING SAME.

BY ALFRED P. MORGAN.

THE rusting and corrosion of iron and steel has always been one of the most serious and yet interesting problems which confront the engineer. There have been various theories offered and numerous remedies, but most of them are scarcely applicable to the conditions which are met outside of the laboratory.

For a long time it was believed that the presence of carbon dioxide was indispensable to the rusting of iron and that the first stage in the process was the formation of a ferrous carbonate. The term corrosion may be defined as a chemical action between iron and some other substance resulting in a direct loss of the metal. While rusting also results in a loss of the metal it may be best interpreted as the slow oxidation of the metal.

Lately the rusting and corrosion of iron has been proven to be an electrolytic action in which the gases dissolved in water play an important part.

Metals do not react at ordinary temperatures with any of the atmospheric gases except in the presence of moisture.

The carbon dioxide present in water does not cause rusting, but rather corrosion and pitting. It is the dissolved oxygen to which the rusting is due. This is borne out by the fact that a piece of polished iron placed in water from which the air has been excluded by boiling, will not rust for a long period, but when pure air free from carbon dioxide is allowed to come into contact with the water, the iron will rust in a few hours.

The experiment of throwing a piece of metallic sodium upon the surface of water, whence it will run around zigzag fashion, growing smaller and smaller until it finally disappears, is perhaps familiar to almost everyone. The action is so rapid that the hydrogen which is cooled often takes fire and burns with a yellowish flame. The reaction is explained by the following equation:

$$\underset{\text{Sodium.}}{Na} + \underset{\text{Water.}}{HOH} = \underset{\text{Sodium hydroxide.}}{\overset{+}{Na}\,\overset{-}{OH}} + \underset{\text{Hydrogen.}}{H}$$

When iron is placed in pure water there is a slight tendency for the iron to take on the ionic form and for hydrogen to be displaced in accordance with the following equation: $Fe^{++} + 2\,HOH = Fe^{++}\,(\overset{-}{OH})_2 + H_2O$. This action proceeds very slowly until the iron becomes coated or polarized with a thin adherent film of hydrogen gas, and the iron being thus shielded from further action of the water, the process comes to a standstill. It is at this point the oxygen plays its rôle, for if some of this gas is dissolved in the liquid, the film of hydrogen gas is oxidized into water. With the removal of the hydrogen film the action proceeds again. In reality, where the oxygen gas previously exists in the liquid a film of hydrogen is not formed and then broken down, but such a protective coating is entirely prevented from forming. The oxygen also performs a second part in which it reacts with some of the ferrous hydroxide and forms ferric hydroxide, thus:

$$2\,\underset{\text{Ferrous hydroxide.}}{Fe\,(OH)_2} + H_2O + O = 2\,\underset{\text{Ferric hydroxide.}}{Fe\,(OH)_3}$$

It is seen that the sodium enters into solution, displacing hydrogen with the resulting formation of a hydroxyl OH ion.

The rate of reaction between a metal and water is dependent upon two factors, the relative solution pressure, i. e., the tendency of the metal to enter into solution, and the ease with which hydrogen is evolved from the surface of the metal. The rate is not necessarily dependent upon either of the facts alone, but on both considered together.

When the sodium reacted with the water and entered into solution it took on a positive charge or became ionic in form. There is a strong tendency for all metals to react thus with water, but the speeds of reaction as stated above are so dependent upon variable factors that the rates vary greatly. For instance, potassium may be exemplified as reacting the most quickly and violently with water, while in the case of platinum the action is so exceedingly slow that it might almost be said that none takes place.

The following experiment gives a marked exhibition of the electrolytic actions described above as taking place in the corrosion and rusting of iron.

EXPERIMENT.

It is obvious that the exceedingly minute quantities of hydrogen evolved would be very difficult of detection, but this difficulty may be circumnavigated by the knowledge that where hydrogen is thus evolved hydroxyl ions must be liberated. The presence of a very small number of hydroxyl ions is easily indicated by a phenol-thalein solution which turns from colorless to red when brought into contact with these ions. Therefore it is the hydroxyl ions which are sought, knowing the fact that in this case where they exist hydrogen is being evolved. In order to detect iron ions we may employ a solution of potassium ferricyanide, the ferricyanide ion of which forms an insoluble blue compound in combination with the iron ions.

As currents in the liquid in which we are to perform our experiment would so mix the red and blue indications that the results would be worthless, we must guard against them by employing a jelly.

This jelly is best prepared by dissolving one gramme of agar agar (a Japanese sea plant) in 100 cubic centimeters of boiling water, to which a few drops of phenolthalein and potassium ferricyanide solution have been added. The potassium ferricyanide solution must be freshly prepared by dissolving some crystals in water as it undergoes changes upon standing for any length of time.

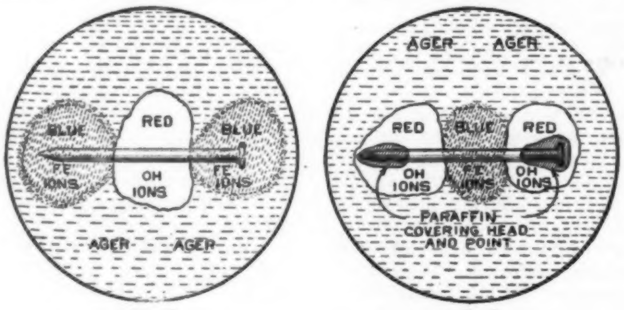


FIG. 1. FIG. 2.

ELECTROLYTIC RUSTING OF IRON.

Enough of the jelly is poured into a large beaker to cover the bottom and it is allowed to cool and harden. Three or four bright iron nails are thoroughly washed in order to remove the slightest traces of any alkali used to neutralize the pickling to which the nails may have been subjected in manufacture. The nails are wiped and placed on top of the hardened layer of jelly in the beaker, and the remainder of the jelly, which has been kept soft by heating over a water bath, is poured over them and allowed to harden.

In the course of two or three hours corrosion due to the moisture present will set in and be made evident by the discoloration of the jelly. Red and blue circles indicating the presence of the hydroxyl and iron ions will be plainly noticeable and present an appearance somewhat similar to Fig. 1. The iron ions seem to exhibit a tendency to go forth from the head and point of the nail. This is probably due to the fact that the nail has there been subjected to stress and strain by cutting and hammering. If the heads and points of the nails are covered with paraffine for a half inch or so, in order that they may be protected from the liquid, they will then throw off hydroxyl ions from the ends as in Fig. 2.

In a process of fusing magnesium and its alloys, which has recently been patented by a German company, the temperature of the metal is not allowed to rise much above the fusing point, and the formation of dross is thus prevented. This result is attained by starting the operation with a small quantity of metal and gradually adding still smaller quantities, so that the melting pot contains some solid metal throughout the entire operation. Thus the temperature is kept near the fusing point and, as a much higher temperature is required to effect combination between magnesium and the oxygen and nitrogen of the atmosphere, no dross is formed. The fused metal is agitated briskly after removal from the fire and up to the moment of casting, in order to facilitate its absorption of heat from the hotter walls of the vessel, and thus to keep it, despite its comparatively low initial temperature, sufficiently fluid to be poured into the mold.

RECIPROCATING AND TURBINE MACHINERY.

THEIR COMPARATIVE WEIGHTS ON SHIPS.

BY N. W. GREENWAY, B.SC.

IN the mercantile marine it may be accepted as an axiom that economy of fuel is the all-important factor to be considered when there arises the question of the most suitable type of propelling machinery to be used in any particular case. Other factors there are, of course, but, speaking generally, the deciding factor in the majority of cases is the economy in fuel consumption. In the navy, on the other hand, while economy of fuel is desirable and necessary, the question of a saving in the weight of machinery is highly important, and has a great influence upon the selection of the most suitable propelling machinery. In the annexed tables are given some collected data which clearly show the increased horse-power per ton of machinery weight in various classes of ships, due to the adoption of turbine propelling machinery. The saving in weight, or horse-power per ton of machinery, in naval ships is seen to be considerable, and in the near future it may be expected that this saving, in war vessels particularly, will become increasingly larger.

The decision of the British Admiralty to forego the use of separate turbines for cruising in H. M. ships (with the exception of destroyers which utilize a great range of power) may still further reduce the weight of machinery in war vessels. The use of such cruising turbines has long been seriously questioned, their additional complication, cost, weight, space occupied, and losses when not in use being hardly justified in the case of many vessels of which the normal power falls not too much below the maximum. Moreover, the economy of such turbines is to a certain degree discounted by steam "tip leakage" losses, as the short blades necessary in these turbines, combined with the requisite clearances, give a proportionately large leakage area. The requisite economy at cruising speeds can be arranged for in conjunction with the main turbines, rows of cruising blades being provided for, and by-passed when not required at higher powers.

Another, and perhaps natural, development is the decision of the Admiralty to try Curtis impulse turbines in H. M. S. "Bristol," one of the new "City" class of protected cruisers, building at Messrs. John Brown & Co.'s Clydebank Works. The results of this experiment will be watched with great interest, and the trials of this ship, when compared with those of the sister vessels fitted with the usual four-shaft arrangement of Parsons turbines (omitting cruising turbines, however), should prove the more interesting in view of the experiences gained on the trials and in the actual running of the United States scouts.

The twin-screw arrangement of impulse turbines offers no advantage in respect of weight, the Parsons system being superior here; and in the question of economy it cannot be said that experience has shown any of the improvement over a wide range of power which may have been anticipated. The multiple-wheel method of constructing impulse turbines would not appear to favor light weight, and from the tables given it is clear that, from the available data to hand at present, the horse-power (equivalent indicated) per ton of total machinery weight works out at about 26.4 for the Curtis machinery of the "Salem," and at least 28.4 for the Parsons engines of the "Chester"; the actual weights (total) of the machinery in the two cases is approximately 800 tons and 740 tons respectively, and for turbines alone 204 tons and 158 tons respectively.

Table I.—Weight of Naval Machinery.

Name of Ship	Type of Ship.	Type of Propelling Machinery.	I. H. P. per Ton of Total Machinery Weight.	Pounds Weight per I. H. P. (Main Engines Only).
Good Hope.	1st class cruiser.	Reciprocating engines.	12.00	......
Mikasa	1st class battleship.	Reciprocating engines.	12.00	......
Cressy class.	1st class cruiser.	Reciprocating engines.	11.67	......
British.......	Battleship.	Parsons turbines.	14.00	42.00
U. S. A.......	Battleship.	Curtis turbines.	12.50	......
Amethyst	Protected cruiser.	Parsons turbines.	26.40	27.40
Topaze.......	Protected cruiser.	Reciprocating engines.	19.40	......
Chester	U. S. scout.	Parsons turbines.	28.40?*	16.80
Salem....	U. S. scout.	Curtis turbines.	26.40	21.65
Birmingham..	U. S. scout.	Reciprocating engines.	17.40	44.20
Hamburg	Protected cruiser.	Reciprocating engines.	17.25†	64.25
Lübeck	Protected cruiser.	Parsons turbines.	24.60†	40.50
Viper.........	Destroyer.	Parsons turbines.	63.80	13.60
Cobra	Destroyer.	Parsons turbines.	57.50	......
H. M. Destroyers with reciprocating engines, best........			45 00	27.10
H. M. Destroyers with Parsons turbines.....			...	10.20
Torpedo-boat (German) with reciprocating engines..			48.87	11.70
Torpedo-boat (German) with Parsons turbines............			. .	10.00

* At least. † Exclusive of auxiliary machinery.

Table II.—Mercantile Vessels.

Name of Ship	Type of Ship.	Type of Propelling Machinery.	I. H. P. per Ton of Total Machinery Weight.	Pounds Weight per I. H. P. (Main Engines Only).
"A"........	Cross-channel ship.	Reciprocating engines.	9.50	. ...
Antrim and Donegal..	Cross-channel ship.	Reciprocating engines.	8.80	74.10
Londonderry.	Cross-channel ship.	Parsons turbines.	11.30	55.20
Manxman....	Cross-channel ship.	Parsons turbines.	12.20	54.60*
Kaiser Wilhelm II	Large pass. liner.	Reciprocating engines.	7.00	..
Deutschland..	Large pass. liner.	Reciprocating engines.	6.86	....
Atlantic	Large pass. liner.	Parsons turbines.	.. .	48.00
"B"	Passenger steamer.	Parsons turbines.	......	61.00
"C".........	Passenger steamer.	Reciprocating engines.	....	86.50
Turbinia. ..	Experimental ship.	Parsons turbines.	91.00	4.06
Steam launch	Engines by Krupp.	Reciprocating engines	36.20	10.35

* Engines + propellers + shafting.

Table III.—Indicated Horse-Power per Ton of Total Machinery Weight.

Type of Ship.	Reciprocating Engines.	Parsons Turbines.
Large armored warships.................	12.00	14.00
Protected cruisers, scouts, etc...........	19.00	25.00
Torpedo-boat destroyers.................	45.00	65.00
Cross-channel steamers.	9.00	12.00
Passenger liners	7.00	.....

The sound construction of the vanes is a strong point in favor of the impulse turbine, and, taken in conjunction with larger tip clearances, should eliminate any possibility of blade fouling and stripping. The general notion that small clearances in these turbines do not matter is, however, not wholly correct; the necessity for reasonably small axial clearances to avoid losses by spreading and spilling of the steam is important, and the clearances between the shaft and the diaphragms—i. e., between stage and stage—must also be kept down.

Table I gives the horse-power per ton of machinery weight for various classes of warships, Table II for merchant steamers, and Table III a summary indicating the most recent practice as regards weight in turbine and piston-engine machinery. No mention has been made of the weight of internal-combustion machinery, as the available data (for small ships only) form no criterion of what can be done on a large scale. It is interesting to notice that for a single-shaft oil-driven machinery arrangement, according to Mr. H. C. Anstey, the horse-power per ton of machinery works out at approximately 12 to 15 for units up to 500 horse-power; and, according to another speaker in the discussion of this subject, for gas-engines the total would be about 7 to 8 horse-power per ton. This makes a poor showing when compared with turbine work for fast vessels, though, as stated previously, the comparison does not rest on all fours.

Considering turbine machinery, further reductions in the weight cannot be expected until some great advance is made in the development of high-speed propellers, or, *vice versa*, in the discovery of some type of turbine more suitable for slow-speed running than present patterns. The turbine problem is inherently bound up with that of the propeller, the present state of compromise being the best that now can be arranged.

The problem of the reversibility of turbines, moreover, seems as yet insoluble, but if a solution is found here again we may anticipate a great reduction in weight. On this point we are reminded of the possibilities of employing an intermediate mechanism, electrical or otherwise, between the turbine and the propeller by which these two components become more adapted to each other; but the economies expected and the possibilities of real success here seem for the present to be doubtful commercially.—Engineering.

THE STEAM CONSUMPTION OF TURBINES.

THE veil of mystery which has surrounded the design of steam turbines is gradually being lifted. At intervals papers are read before the various learned societies which throw more light upon this subject. One of the most recent of these contributions is entitled "A Method of Determining Pressures for Steam Turbines," and was read before the Society of Naval Architects and Marine Engineers in America by Prof. C. H. Peabody. In this paper the author describes a method of equalizing the adiabatic heat fall in different stages of a turbine. He applies this method in the first instance to a two-stage and then to a six-stage Curtis turbine. The object in view is to have the same velocity in the nozzles of all the stages. Merely dividing the abiabatic heat fall between admission and exhaust into equal parts does not give true results, for the simple reason that some of the heat not converted into work in one stage is utilized in subsequent stages. The error, however, is only in the neighborhood of 3 per cent. There is no great difficulty in correcting this error by a method of trial and error, but Prof. Peabody has devised an ingenious albeit rather cumbersome scientific method of arriving at the desired result. His method is apparently more direct than the method usually employed, but it involves much recourse to steam tables, not to mention the interpolation of numerous entropies. We think the designer will prefer the simpler and in reality more expeditious method of trial and error.

There is, however, an extremely simple graphic method of arriving at the desired result by using Mollier's well-known heat entropy chart. It so happens that on this chart the condition line of the steam as it passes through the turbine from stage to stage is represented by a curve so flat that for all practical purposes it may be taken as a straight line, and this curve can be laid down as soon as the stage efficiency ratio has been determined. The points of equal adiabatic heat fall for each stage are almost equidistant on this condition line, and the small correction necessary can be effected by inspection. We have calculated Prof. Peabody's six-stage example by this method, and have arrived at a somewhat more accurate distribution of the heat fall than he has. The operation took something under fifteen minutes, whereas the professor's method could hardly be computed under an hour. Further, the Mollier chart method can be applied with equal ease when the admission steam is superheated, whereas Prof. Peabody only shows how his method can be applied with saturated steam, and it is difficult to see how it would work with superheated steam. It is to be noted that Prof. Peabody, in working out his numerical example, assumes an efficiency ratio of 65 per cent, which, incidentally, he terms the "overall internal heat factor." He also discriminates between the efficiency ratio of each stage and the overall efficiency ratio of the turbine, and seems to think that this distinction is new. In this, however, he is in error, as the distinction is well known, at any rate on this side of the Atlantic. It is further to be observed that the 65 per cent efficiency ratio which he takes is determined by comparing the assumed economy of a turbine with the corresponding Rankine engine.

This leads us to point out the considerable difference which lies between the predetermination of the steam consumption of a reciprocating engine and that of a turbine. In the case of the former the losses are deemed to consist principally of leakages and condensation, which is partially recovered by re-evaporation; but, unfortunately, these losses are so intermixed that it has so far been impossible to disentangle them. We need not elaborate this point, as it is well known to engineers, and has been referred to on many occasions in these columns. In the case of the steam turbine, however, the various losses, which are principally leakage and steam friction, can be measured separately by suitably devised experiments. This has already been done to a certain extent, and formulæ by which these losses may be estimated have been established by Stodola and others. Undoubtedly, also, the various turbine manufacturers have data of their own which they do not make public. It is therefore possible in the case of a steam turbine to estimate the losses with considerable accuracy, and then by comparison with the corresponding Rankine engine the steam economy can be readily obtained. The experiments to determine the losses in a steam turbine are still, however, somewhat meager, and it would be of great advantage if an exhaustive series of such experiments could be made. Would it not be possible for our technical colleges to collaborate in this matter, each undertaking a definite portion of a well-considered scheme of investigation?—The Engineer.

THE GREAT GUNNISON IRRIGATION PROJECT.

THE COMPLETION OF THE IRRIGATION SYSTEM OF THE UNCOMPAHGRE VALLEY.

BY ALBERT WILHELM.

THE most notable project for irrigation in the West yet undertaken by the United States Reclamation Service has now been completed, and at the close of the present year fully 200,000 acres of arid territory in southwest Colorado will be reclaimed as the result.

This is called the Gunnison project for the reason that the waters of the Gunnison River have been made available for the purpose. The territory in question served by the river comprises a large portion of the Uncompahgre Valley, a part of which has been supplied with water from the river of the same name, a shallow sluggish stream which has been entirely inadequate for the purpose. The Gunnison flows through the Gunnison Gorge a distance of about 20 miles from the valley, and to make it available one of the most remarkable engineering feats on record was successfully carried out—the location of a route for a tunnel through the mountain wall which separates the river from the valley, and the excavation of a tunnel which is over six miles in length, connecting with an open canal about 20 miles in length, which in turn will serve nearly 100 miles of laterals and ditches.

While it was necessary to make what is the largest irrigation tunnel in the world to divert the river, the latter's entrance to the tunnel was located under extreme difficulties, for the reason that it is situated in what is known as the Black Canyon, which varies in depth from 1,000 to fully 3,000 feet, in many places the walls being almost perpendicular, while the gorge narrows here and there to a width of less than 50 feet. Consequently, the surveys necessary were made with great difficulty as well as danger. When the engineers of the Reclamation Service in this district were ordered to locate a route, an expedition was organized. This descended into the upper gorge, but was only able to make its way a few miles when it reached a point where boats could not be used and the supplies were exhausted. The party then retraced its steps, and after much difficulty climbed out of the canyon, although so steep are the sides that it was necessary to use ropes to make the ascent as well as portions of the descent.

Not discouraged, however, two of the engineers determined to resume the exploration. Entering the head of the canyon, they covered the route of the first expedition. Here they worked their way by climbing over rocks, wading, swimming where necessary, and at one point actually passed under a natural bridge formed by a fall of rock in the canyon. At another point they were obliged to swim a waterfall nearly 20 feet high, but in each case escaped with their lives, although hurled by the rushing torrent against the rock ledges and boulders in the stream and badly bruised. In all, no less than ten days were taken in going through the gorges, and the engineers were the first white men who have ever explored what is known as the Black Canyon and returned alive in spite of the dangers from the rapid current and the rock-strewn channel, which cause rapids, even whirlpools, where an expert swimmer could not survive.

Messrs. A. L. Fellows and W. W. Torrence, the engineers who performed this remarkable feat, were successful in keeping their instruments unharmed, and secured enough measurements to locate the Gunnison end of the proposed tunnel at what is now known as River Portal. The next step was to make this place available for excavation work, also to provide a site for the power house, since the entrance to the proposed tunnel was directly in the side of the wall, with no ledge or other outcrop below it. A road to carry machinery and other material was absolutely necessary, so the first work done was to construct a thoroughfare 12 miles in length from the valley over the mountain wall and to the proposed entrance. The building of this road in itself was a remarkable engineering feat. Up the Uncompahgre side the road winds, as any other mountain road, but on the other slope parts of it had to be blasted out of solid rock. It is the only wagon road into the canyon for 70 miles. The grade is so steep that the four-horse wagons going over it present the appearance of being all brakes. In places it drops down as much as 22 feet in 100. Over this road was hauled all the machinery for the power house, the rails, wire, motors, and cars for the tunnel, all the building material and food supplies for the town, and hundreds of tons of coal. Most of the hauling was done in the summer, for the top of the divide is two or three feet deep in snow in winter. At the bottom of the gorge River Portal is built on an artificial base, made partly on the refuse taken from the tunnel and partly on the side of the gorge, where each house has to have an embankment made to give it room to stand.

With the road completed excavation was begun by a private company, but it gave up the undertaking as impossible. The Reclamation Service then took up the project, with the result that after six years' work the opening has been completed, although, as stated, under great difficulties. Drills and other excavating machinery driven by electric power have been utilized, and it is largely due to the use of modern machinery that the enterprise has been successful. Although the formation in places is very hard, no less than 8,500 feet of the tunnel has been completed in a single year, while an average of over 700 feet in a month has been attained. In the progress of the work, however, the excavators have met with unexpected obstacles. In the western section a blast opened the channel of an underground stream of water, which poured into the opening and compelled the men to flee for their lives. Such was the flow of water that it was necessary to make test borings to discover its extent, and a conduit had to be made to drain it. The subterranean opening was filled with carbonic acid, and compressed air had to be forced into the tunnel to prevent the laborers from being overcome.

Intense heat affected the excavators to such an extent that an air shaft 400 feet deep had to be sunk from the surface to ventilate the heading. This required three months of work alone during which operations in the tunnel had to be postponed. In another part of the excavation a bed of shells and sand fully 500 feet in depth was encountered, necessitating extensive shoring and propping with timber. Here occurred the most serious accident in the progress of the work, a collapse of the false work, confining 32 of the men in the heading. Fortunately, the air pipe was not injured, and during the three days and nights that they were imprisoned, they were kept from suffocation by this means. When rescued it was found that six were dead, having been killed by masses of falling rock.

The tunnel is the third longest in the United States, two railroad tunnels exceeding it. The volume of water it will carry can be estimated when it is stated that the interior has a diameter of no less than 12 feet. Consequently, it is one of the most capacious irrigation conduits which has yet been constructed. Extending from River Portal to the edge of the Uncompahgre Valley, it will deliver a volume of water estimated at 1,300 cubic feet per second, and serve an area embracing over 200 square miles. Connecting with it are a series of canals most of them lined with concrete, provided with suitable water gates and sluiceways. In fact, the Uncompahgre is one of the most complete canal systems which has been projected by the Reclamation Service, but it has been demonstrated already that the soil can be made very fertile, producing as many as four and five crops of alfalfa yearly in addition to various fruits, vegetables, as well as wheat of a very high grade. The project ranks with the Roosevelt in Arizona and other of the great irrigation enterprises in the area of land which it will serve. It has been under the supervision of Mr. I. W. McConnell of the Reclamation Service, with Mr. C. T. Pease directly in charge.

VIEW OF THE MAIN IRRIGATION CANAL ON UNCOMPAHGRE SIDE FROM GUNNISON TUNNEL.

LINING AN IRRIGATION CANAL IN THE UNCOMPAHGRE WITH CEMENT.

THE GREAT GUNNISON IRRIGATION PROJECT.

FLEXIBLE CRANK AXLES.

THE crank axle is the weakest member of the machinery of a locomotive, in the sense that it is that part most liable to fracture. It has been said that if only the fire-box would last as long as the engines the life of a locomotive would be wearisomely prolonged. The crank shaft is the exception to the general rule, and this is one reason why the outside cylinder is popular. The crank axle usually breaks somewhere about the webs. The pins separate from them, or they break away from the body of the axle, or the webs will break straight across. To guard against this it is a usual practice to shrink steel hoops round them. There is a very old fable about the oak and the reed. In a storm the oak was torn up by the roots, and, dying, it asked the reed how it had escaped. "By bending to the storm," was the answer. This principle has been invoked over and over again in the case of

crank axles; and various methods of imparting elasticity have been tried always with a certain amount of success. The simplest plan is to make the crank webs thin. But if they are thinned sufficiently they are apt to give way in the plane of rotation instead of transversely. Mr. Thomas Worsdell, of the North-Eastern, therefore patented a crank axle with circular disk webs, which can be made quite thin, and have nevertheless enough metal in them for strength. The well-known oval crank cheek effects the same purpose, but not so efficiently.

Recently in France a new flexible crank axle has been tried apparently with great success, and has been made the subject of a report prepared by M. Ed. Sauvage for the Comité des Arts Mécaniques. The report is based on the proposals of M. Charles Fremont, who has submitted to La Société d'Encouragement particulars and specimens of his invention. Several crank shafts were sent for examination both of the ordinary four-web and the French two-web or "Z" type. They had cracks occurring for the most part at the junction of the crank pin with the web, or the junction of the last with the main body of the axle. M. Sauvage explains that failure is almost invariably gradual; a minute crack starts, and extends by degrees under the influence of the longitudinal shocks to which the axle is exposed by the impact of the flange against the inside of the rail, and particularly by the striking of the inside of the tire against guard rails at crossings. The cracks manifest themselves after variable terms of service. They are always small at first, and go on spreading. Superficial at the onset, they gradually become deeper; but how deep there is no means of knowing until the axle breaks. After a time the axles have to be withdrawn from service. M. Sauvage is positive that the failures are always due to endlong shocks or stresses acting "perpendicularly to the line of road." M. Fremont argues that when a portion of a machine receives a shock the work corresponding should be absorbed by the elastic deformations of the piece, otherwise permanent set will be imparted. But the longitudinal stresses to which a crank axle body is exposed cannot produce elastic or any other deformation. The crank cheeks again are very stiff; and the result is that the mischief is concentrated about the angles where the cylindrical portions are united to the web. To get over this M. Fremont uses broad webs thinned away in the middle of their length. Furthermore, a large aperture is made in the center of the web, which, while retaining to the full its power to resist the torsional effort of the piston, becomes so far weakened as regards transverse shocks that it can freely respond to them. With the Worsdell circular web he attains the result by making a large aperture, resembling in form a dumb bell in section in the web, which otherwise remains unaltered, being fitted with a hoop shrunk on in the normal way.

The position of M. Sauvage as assistant mechanical engineer-in-chief of the Western Railway of France imparts weight to his utterances. He is altogether in favor of combating, by imparting elasticity, the stresses which break crank axles, holding that to attempt to fight them by brute strength must lead to disaster in the long run. Also he holds that M. Fremont appears to have hit on a very satisfactory solution of this difficulty, even going so far as to say that axles which are already slightly cracked may be continued in use if the crank webs are bored and slotted out as proposed. It is unnecessary to remove the wheels, and the cost, everything included, is given by M. Sauvage as only 87f., or say, £3 10s.; quite insignificant when compared with the value of the further service which can be had from the axle. It seems that on the Southern Railway of France five cracked axles have been thus kept in service. These engines had run distances varying from 106,000 to 212,600 miles from the time they were put to work until the cracks were discovered. Subsequently they ran further distances varying from about 32,000 to 81,000 miles. The webs were then "modified," and since they have run from 90,000 to 114,000 miles up to the 31st of March last. An interesting fact about the first of these axles is that it showed when the web was bored out the existence of an old crack. Careful examination has proved that since the operation there has been no extension of this fissure. Four new crank axles made on this system have already run large mileages—125,400 in one case—the most careful examination failing to discover any symptoms of cracking. M. Sauvage's final conclusion is that M. Fremont's system is logical. It augments the life of crank axles, and improves all the conditions of their service.

There is, we think, very little to criticise in this report. No one, so far as we are aware, disputes the vital importance of imparting elasticity to a crank axle. The question for solution is the best method of doing it. In effect the removal of a large part of each web seems to be much the same thing as boring out crank pins and crank shafts in marine work. We are not aware of any instance in which the crank pins of locomotives have been bored out. The stresses are quite different in many respects from those to which a marine crank shaft may be subjected. Many locomotive engineers hold that if only the steel is really good, nothing more is needed than the normal hooped web. This is, we think, a mistake. In large modern engines it has been found almost indispensable to fit a central bearing to take fore-and-aft stresses. But this can only partially deal with the shocks, which M. Fremont eludes. Mr. Ivatt, of the Great Northern, is now exhibiting at the "White City" a very novel crank axle.

M. Sauvage does not say whether the engines running with cracked axles are goods or passenger locomotives. In either case a notable divergence from English practice is manifest. We do not think it would be easy to find a locomotive superintendent in this country who would take the responsibility of keeping in service a cracked crank axle. He would get little mercy from a board of trade inspector if an accident took place. We may, however, profit by amiable indiscretions of our neighbors, and gather increased confidence in the Fremont system from the fact that it will keep even cracked axles going for an apparently indefinite period.—The Engineer.

A CANAL CONNECTING THE TUNNEL WITH THE IRRIGATION SYSTEM, SHOWING CONCRETE SPILLS AND RETAINING WALLS.

BIRD'S EYE VIEW OF GUNNISON RIVER WHICH WILL BE CARRIED THROUGH THE TUNNEL INTO UNCOMPAHGRE VALLEY.

DIGGING OUT THE DESERT WITH MACHINERY AND LINING IT WITH CONCRETE FOR THE CANAL.

INTERIOR OF THE TUNNEL, SHOWING THE PIPE FOR FORCING AIR INTO OPENINGS.

THE GREAT GUNNISON IRRIGATION PROJECT.

RECENT ELECTRICAL PROGRESS.*

THE ARTIFICIAL LIGHTING FIELD.

BY ALBERT F. GANZ, M.E., PROFESSOR OF ELECTRICAL ENGINEERING, STEVENS INSTITUTE OF TECHNOLOGY.

ONE hundred years ago Sir Humphry Davy exhibited the first voltaic arc before the Royal Institution of London, and this may be said to mark the birth of the electric light. This Davy arc was produced between wood-charcoal electrodes, by means of a powerful voltaic battery of copper-zinc cells, and was at best a brilliant lecture-room experiment. Subsequently he inclosed the electrodes in a glass vessel, from which the air was exhausted to prevent combustion of the charcoal points. No attempt to use the electric arc as a source of light was made, however, until about 1844, when a French physicist, by name of Foucault, produced an arc between electrodes made of gas retort carbons by means of a large Bunsen battery. Foucault produced a remarkably steady and continuous arc light, which he exhibited publicly in Paris, and, indeed, used this arc light for lighting the stage of the Paris Opera House during a performance of the opera, and for lighting a number of public squares in Paris. This is the first time that the possibility of using electric light for lighting houses and streets began to be considered. The expense and trouble involved with the use of batteries, as well as the necessity of controlling the lamps by hand, soon discouraged any attempt to use the Foucault arc lamp for commercial lighting. In 1845 Thomas Wright of London produced the first arc lamp in which the carbons were automatically regulated, the carbons being in the form of disks, which were slowly rotated by clockwork. This was followed by the development of various types of regulating mechanisms, by many investigators in Europe and in America, who used various devices for striking the arc and feeding the carbons as they were consumed.

In 1831 Michael Faraday discovered the principle of electromagnetic induction, and this discovery was followed by the invention of early forms of magneto-electric machines. These machines made it possible to obtain powerful currents in a simpler and cheaper manner than was previously possible with batteries, and a number of attempts were made to employ such machines for arc lighting. One of the first important applications was made in 1858 by the Lighthouse Department of England. This department, under the direction of Faraday, successfully introduced the electric light in its important lighthouse at South Foreland, employing the Alliance dynamo, devised by Nollet and Van Malderen, of Belgium. It is an interesting historical fact that the Alliance dynamo thus employed for supplying current to an electric arc light was built originally for the purpose of decomposing water, in order to employ the resulting gases to produce a powerful lime light.

In 1876 Jablochkoff brought out his celebrated electric candle, and obtained patents for this all over the world. The Jablochkoff candle was marked by the absence of any regulating mechanism. It consisted, broadly, of two vertical sticks of carbon separated slightly by an insulating material, such as kaolin, which was consumed at the same time as the carbons. These lamps were found to burn best with alternating current, which insured an even consumption of the carbons. They were soon to be seen burning on the streets of European cities, and found popularity in the United States as well, one of the first places in this country in which they were employed being the store of John Wanamaker, in Philadelphia. While a number of these Jablochkoff candle installations were made they were actually used for a comparatively short time only.

The introduction of the Gramme dynamo-machine in 1871 marked a new era in electric lighting on both sides of the Atlantic, and inventors began to develop direct-current dynamo machines and arc lamps operated by these machines. Prominent among the early American inventors in this field may be mentioned Weston, Brush, Thomson, Houston, Wallace, Farmer, Wood, Hochhausen, and others. During the following ten years a number of direct-current dynamo machines were developed for supplying current to arc lamps. These machines were designed to supply at first a single lamp, while later machines were made to supply as many as 50 lamps in series. Lamps employing two pairs of carbons were also introduced, so that when one pair became consumed the other would be automatically cut in, thus continuing the lamp in operation until both sets of carbons were consumed, and so reducing the labor of trimming.

It is interesting to note that, in 1876, at the Philadelphia Centennial Exposition, a portion of the Exposition buildings and grounds was illuminated by a few electric arc lamps supplied from a Wallace-Farmer dynamo-electric machine.

One of the earliest attempts to utilize a wire heated to incandescence by an electric current as a source of light was made by Grove, the inventor of the battery which bears his name, and is described in the Philosophical Magazine for 1840. Grove's lamp was, of course, of very crude form, consisting of a spiral of platinum wire attached to two copper supports and inclosed in a cylindrical glass jar inverted in a shallow dish of water. Grove states in his paper that he succeeded in reading for many hours by the aid of this lamp. In 1841 De Moleyns, of England, patented an incandescent lamp which consisted of a platinum wire inclosed in an exhausted bulb and rendered incandescent by an electric current. A few years later, Starr, of Cincinnati, devised a lamp in which a thin strip of graphite, connected to two conducting wires of platinum, was suspended in an exhausted glass globe and rendered incandescent by an electric current. This lamp involved in fact the essential elements of the carbon filament lamp of to-day. No practical lamp resulted, however, from these early experiments.

About 1875 a number of investigators set their energies to the development of a commercial incandescent lamp, and produced some practical lamps, but these lamps were not introduced in actual practice until about 1880. Prominent among the workers in this field at this time were Weston, Sawyer, Man, Edison, Maxim, and others.

By the year 1880 a number of direct-current dynamos had also been developed for supplying incandescent lamps in multiple at constant voltage. The great interest which had developed by this time in the electrical industries gave rise to the first International Electrical Exposition which was held in Paris in 1881. At this Exposition most of the prominent inventors and manufacturers in the electrical fields of the world exhibited their inventions and products. A good description of this Exposition is found in a government report, made by Major David Porter Heap, of the Corps of Engineers, United States army, and published by the Engineer Department, United States army, in 1884. A complete history of electric illumination from the earliest beginnings to the year 1881 is also found in a large work by James Dredge, entitled "Electric Illumination," and published in 1882 by John Wiley & Sons, of London and New York.

From this time to the present the development in the electric lighting field has been enormous. This progress has been well recorded by Mr. T. Commerford Martin, in the Annual Reports of the Committee on Progress of the National Electric Light Association. The development, up to 1902, is also well set forth in the Special United States Census Report, on Central Electric Light and Power Stations, issued in 1905 by the Department of Commerce and Labor. Some of the data contained in the following have been obtained from the above reports. Electric lamps have been developed along three distinct lines, namely, arc lamps, incandescent lamps and vapor lamps. The progress since 1880 is conveniently considered under the separate headings of "Development of Arc Lamps," "Development of Incandescent Lamps," "Development of Vapor Lamps," and "Development of Machinery and of Systems of Distribution."

Development of Arc Lamps.—The series direct-current open arc lamp was the most generally used arc light for street illumination up to the late nineties, and quite a number of these are, in fact, still in use. These open arc lamps operate generally with a short arc taking from 40 to 50 volts. The upper carbon is made the positive electrode, and practically all of the light comes from the incandescent crater of this positive carbon, the arc itself being non-luminous; the greatest intensity of light is projected at an angle of about 45 deg. downward. These open arc lamps were developed in two sizes, the larger size taking 9.6 amperes, or about 450 watts, and formerly known as the normal 2,000 candle-power lamp or "full-arc," and the smaller size taking 6.6 amperes, or about 325 watts, and formerly known as the normal 1,200 candle-power lamp or "half-arc." This does not mean, however, that these lamps actually give a light of 2,000 and 1,200 candles respectively, but these ratings have become trade names. Dr. Bell states that the 9.6-ampere lamp gives about 1,300 candles in the direction of maximum intensity, and a mean lower hemispherical candle-power of about 600; and that the 6.6-ampere lamp gives about 700 candles in the direction of maximum intensity and a mean lower hemispherical candle-power of about 350.

For a time the size of an electric arc lamp was expressed in terms of watts consumed in the arc, and specifications for street lighting were frequently drawn up on this basis. With the introduction of inclosed and flaming types of arc lamps this method was necessarily abandoned. The present practice is to express the light intensity in mean spherical candle power and the specific power consumption in watts per mean spherical candle. This specific power consumption is frequently called the efficiency of a lamp, but it is actually the reciprocal of efficiency. Special integrating photometers have, in fact, been devised whereby mean spherical candle power can be quickly determined from a single photometer setting. In some cases mean lower hemispherical candle power is measured and the specific consumption is expressed in terms of watts per mean lower hemispherical candle. This is frequently done in the case of lamps which are so designed as to project all of the light into the lower hemisphere.

Series arc lamps operating on constant-alternating current circuits have also been introduced, especially since the constant-current transformer was developed in 1902. In the alternating current arc each carbon becomes alternately positive and negative, and the reversals of current must be sufficiently rapid so that the arc is not extinguished between reversals and that there are no disagreeable fluctuations. This condition necessitates a frequency of at least 40 cycles per second, and in practice a frequency of 60 cycles or 120 alternations per second is most frequently employed. Owing to the fact that the light is emitted from the incandescent tips of both carbons the light is distributed equally in the upper as well as in the lower hemisphere. An alternating current arc lamp also gives very much less total light than a direct current arc lamp consuming the same number of watts.

In 1893 Mr. Louis B. Marks described the inclosed type of arc lamp, in a paper presented at the International Electrical Congress, held in Chicago in that year. The inclosed arc lamp quickly met with favor in America and soon began to supersede the open arc lamp. In the inclosed type of arc lamp the arc is surrounded by a small globe of refractory glass, in the bottom of which is fastened the lower carbon and through the top of which the upper carbon moves freely in a stuffing-box arrangement. By this means access of air to the arc is restricted and the inclosure quickly fills with heated gases with the result that the arc takes from 70 to 80 volts with a reduced current and the carbons burn away much more slowly than with the open arc. The gases inclosed in the inner globe are heated to incandescence in the vicinity of the arc, so that the entire interior of the globe appears to be incandescent, thus giving a very much better distribution of light than with the open arc. The total quantity of light emitted from an inclosed arc lamp is very much less, however, than that emitted from an open arc lamp taking the same number of watts; but, owing to the more uniform distribution of the light, a better general illumination is produced and the color of the light is also more nearly white. A pair of carbons will last about 100 hours in an inclosed arc lamp, but only from 5 to 10 hours in an open arc lamp; there is, therefore, a great saving in carbons and in labor of trimming with the inclosed arc lamp over the open arc lamp. This is the principal reason why the inclosed arc has almost entirely superseded the open arc in America. In Europe, where carbons and labor are cheaper, the inclosed arc has not met with favor, because of its much lower light efficiency. Inclosed arc lamps are used both for street lighting and for interior lighting of shops and stores, for which latter class of lighting the whiteness and uniform distribution of the light make them preferable to open arc lamps.

The electric arc lamp is inherently a constant current device, because the electric arc has the characteristic of decreasing in potential difference with an increase of current. The early arc lamps were, therefore, constructed to operate in series from constant current dynamo machines, thus requiring a high line voltage, which was permissible for street lighting for which such lamps were exclusively used. In the beginning of the nineties arc lamps began to be constructed to operate on constant potential circuits with incandescent lamps. For indoor lighting by arc lamps the constant potential inclosed type of lamp is

* Reprinted from the American Gas Light Journal.

now almost exclusively used. An arc lamp, in order to operate on a constant potential circuit, requires the addition of sufficient resistance in series with the arc, so that to increase the current it is necessary to increase the voltage. For this reason constant potential arc lamps are necessarily less efficient than constant current arc lamps, and this decrease in efficiency amounts to about 30 per cent in a direct current lamp. In a constant potential, alternating current arc lamp the loss in power is less, because a reactance is used instead of a resistance, but the power factor of the lamp is greatly lowered.

The relative specific power consumption of various types of carbon arc lamps of average size are given by Dr. Bell as follows:

Type of Arc.	Watts per Mean Spherical Candle.	Remarks.
Direct current, open series lamp	1.0	Medium power arc.
Direct current, shaded series lamp	1.3	Medium power arc.
Direct current, inclosed series lamp	1.9	Approximate.
Alternating current, open series lamp	1.7	Approximate.
Alternating current, shaded series lamp	2.2	Approximate.
Direct current, inclosed multiple lamp	2.4	No outer globe.
Direct current, inclosed multiple lamp	2.9	Clear outer globe.
Direct current, inclosed multiple lamp	3.3	Opal outer globe.
Alternating current, inclosed multiple lamp....	3.0	Clear outer globe.
Alternating current, inclosed multiple lamp....	3.6	Opal outer globe.
Alternating current, inclosed multiple lamp....	2.5	No outer globe.

During the latter part of the nineties a type of arc lamp was introduced by Bremer in Germany and by Blondel in France, in which metallic salts, principally salts of calcium, were added to the carbons. In the operation of the lamp the metallic salt is vaporized and rendered incandescent, thus producing an arc which is highly luminous and of an orange-yellow color when calcium salts are used. These new lamps are called flaming arc lamps.

Two distinct types of flaming carbon arc lamps have been developed. In the first type, due to Bremer, the carbons converge downwardly, the arc forming between the bottom tips of the carbons, a blowing magnet placed above the arc sometimes being used to project the arc downward, thus preventing the arc from climbing up on the carbons. This produces a long arc and gives a downward distribution of the light. In the lamp, as brought out by Bremer, the material of the carbons was mixed with salts of the calcium group. This type of lamp, with downwardly converging mineralized carbons, has been adopted by a number of manufacturers and is largely used. In the second type of flaming carbon arc lamp, due to Blondel, the carbons are placed in a vertical line one over the other, as in an ordinary arc lamp. This results in more light being projected in a horizontal direction and, therefore, gives a better distribution of light than is obtained with the first type of lamp. The electrodes are made of pure carbon provided with a core containing the minerals to be vaporized in the lamp.

Besides calcium compounds, titanium compounds have also been used, giving the arc a white color. The titanium arc is, however, not as efficient a light giver as the calcium arc. The effect of adding calcium or titanium salts to the carbons is, however, to produce fumes which prevent the inclosing of the arc in a small glass chamber. These flaming arcs must, therefore, burn in the open air with the result that the carbons have a short life and require frequent trimming. These flaming arc lamps have been very largely used for street lighting in Europe since 1900. During the past five years such flaming arc lamps have also been introduced in America; they are not generally used here for street lighting, however, but rather for lighting the fronts of shops, theaters, etc., for advertising purposes. Although the flaming carbon arc lamp gives more than three times as much total light for the same number of watts as the inclosed carbon arc lamp which is used generally for street lighting in America, the high cost of the carbons and of trimming due to the high cost of labor in this country, has been largely responsible for preventing the introduction of this lamp for street lighting in American cities. Flaming arc lamps can operate on direct or on alternating current and can also be constructed for constant current or for constant potential circuits.

A striking example of street illumination by flaming carbon arc lamps is found in South Broad Street, Newark. The merchants along three blocks of this street combined with the electric light company to replace the 21 alternating-current inclosed arcs which were used for lighting this portion of South Broad Street, by 35 powerful flaming carbon arc lamps, spaced 60 feet apart. These powerful lamps produce a flood of light, attracting attention to this portion of South Broad Street.

While flaming carbon arc lamps have been commercially in use for less than ten years it is a noteworthy fact that even before 1880, various investigators in Europe and in America had experimented with carbon arc lamps in which the carbons were treated in various ways with mineral salts so as to produce a luminous arc. Prominent among these early investigators was Edward Weston, who in 1878, secured a patent for this type of arc lamp and actually constructed a considerable number of them. The yellow color of the light and the fumes produced were objected to, however, and these lamps were not generally introduced.

About 1904 a new type of luminous arc lamp was introduced by the General Electric Company, called the magnetite lamp. This lamp was developed with the object of producing an arc lamp which would combine the high efficiency of the carbon flaming arc lamp with the long life of the carbons of the inclosed type of carbon arc lamp. A similar lamp, manufactured by the Westinghouse Company, is known as the metallic flame arc lamp. This type of lamp can operate only on direct current, and is also known as the direct current luminous arc lamp. The negative electrode consists of magnetite mixed with some titanium salts and compressed into a solid rod, or packed into a thin steel tube. The positive electrode may be any stable conductor and consists in practice of a short piece of copper. A long arc is drawn in this lamp requiring about 75 volts, the electric current being carried through the vapor stream which issues from the magnetite electrode, and this is slowly consumed. This incandescent vapor stream is the main source of light, the luminous intensity being principally due to selective radiation from the incandescent vapor, with the result that the light emitted is of intense brilliancy and whiteness. The lamp as generally used requires 4 amperes and gives a total amount of light somewhat greater than that given by the 6.6-ampere inclosed direct-current arc lamp, or the 7.5-ampere inclosed alternating-current arc lamp, with a corresponding saving in electric power. With this current the average life of a magnetite electrode is about 175 hours. More recently magnetite lamps using 6.6 amperes have been introduced in which the life of the magnetite electrode is about 75 hours. The copper electrode is not consumed, and in practice lasts several thousand hours.

A prominent example of an installation of large magnetite lamps is found in Boston, where recently a large number of 6.6-ampere direct-current inclosed carbon arc lamps have been replaced by 6.6-ampere magnetite lamps, lamp for lamp. These magnetite lamps are being operated from the same Brush arc generators which were used with the carbon arc lamps. The same amount of electrical power is, therefore, supplied, but more than double the total illumination is produced by means of these magnetite lamps.

The attempt to produce an equivalent of the magnetite lamp, which would operate on alternating current directly from a constant current transformer, has resulted in the titanium carbide lamp, known also as the alternating-current luminous arc lamp, which has been placed upon the market quite recently. This lamp is described by Mr. N. R. Birge, in a paper entitled "The Present Status of the Arc Lamp for Street and Interior Illumination," presented before the 1909 convention of the National Electric Light Association. The upper electrode is titanium carbide compressed into a steel tube. The lower electrode consists of two half-round carbon rods, inclined at an angle, and kept in abutment at the top and in a fixed position by metal fingers forced against the bases. This arrangement maintains the upper ends of the lower carbons and the arc in a fixed position. The upper or titanium carbide electrode is arranged to be separated from the lower electrode by a lifting magnet when the lamp starts, but no feeding mechanism is provided in the lamp. These lamps are designed to operate in series from a constant current transformer. In order to provide for feeding the titanium carbide electrode, an arrangement is introduced in the circuit on the station switchboard whereby the circuit is instantaneously interrupted by means of an oil switch, automatically operated at intervals of about 20 minutes, thus allowing the titanium carbide electrodes to feed down in each lamp of the circuit. By this arrangement the lamp mechanism is greatly simplified, and it is claimed that the periodical interruption of the circuit is so quickly performed that there is no appreciable effect upon the light of the lamp. In the operation of the lamp both electrodes are consumed, the sizes being so chosen that they need replacing at the same time. The first alternating-current luminous arc lamps were designed to operate on 2.5 amperes, so as to give about the same amount of light as the inclosed 7.5-ampere alternating-current arc light ordinarily used in street lighting; but lamps for currents of 3 amperes and 4.5 amperes respectively, giving a larger amount of light, are being constructed, for which currents the life of the electrodes is claimed to be about 75 and 50 hours, respectively.

An attempt to produce an inclosed form of flaming carbon arc lamp resulted in the Jandus regenerative flaming arc lamp, which was brought out in England about two years ago. The arc is surrounded by a cylindrical chimney of refractory glass, which opens at the top and at the bottom into metal chambers, which in turn communicate with each other by two curved tubes placed on opposite sides of the glass globe. When the lamp is in operation the hot gases from the arc rise into the upper metal chamber, and, becoming cooled, pass down through the two vertical tubes, depositing the solid particles on the walls of the tubes so that the vapor which enters the chamber from below is freed from these particles. The object of this arrangement is to inclose the arc, restricting admission of air and giving a long life to the carbons, and also to produce a higher temperature of the incandescent vapors. This inclosed type of flaming arc lamp is described by Mr. A. J. Mitchell, in a paper read before the National Electric Light Association, at its annual convention in 1909. A lamp of this type has recently been placed on the market in America for which a life of 70 hours of the carbons has been claimed.

A number of carbon arc lamps have been developed in Germany and in France, in which the carbons are made of comparatively small diameter, in order to raise a large portion of the carbon tips to incandescence, and in this way obtain a whiter and more efficient light and also to obtain a better distribution of light. These lamps are principally designed in small sizes, taking a small current, to be used for interior illumination, for which purpose flaming arc lamps are not generally desirable. A lamp of this type, known as the "intensified carbon arc lamp," has recently been placed upon the market in America, and is described in the paper by Mr. N. R. Birge, referred to above. This lamp consists of a lower negative carbon, of large diameter, and a pair of upper positive carbons of small diameter, inclined at an angle to each other. The upper portion of the lower or negative carbon is kept in a fixed position, while the two small positive carbons are arranged to draw the arc on starting and to feed downward, as they are consumed. In this way the arc is centered in a definite position, so that a reflector can be used for the purpose of projecting the light entirely in the lower hemisphere. The arc is also inclosed by a large hemispherical globe, restricting the access of air, and thereby giving the advantage of the long life of the carbons of an inclosed arc lamp.

Development of Incandescent Lamps.—In the consideration of the development of incandescent lamps it will be convenient to briefly point out the relation between specific power consumption and useful life. Incandescent lamps are commercially rated in terms of watts consumed per mean horizontal candle. It has been found that incandescent carbon filaments gradually volatilize, resulting in a reduction of light and a decrease in efficiency. Experience has shown that it does not pay to operate a carbon filament lamp after it has been reduced to about 80 per cent of its initial candle-power, which point is sometimes called the "smashing" point. The useful life of the lamp, which is the number of hours that it will burn before it reaches this point, depends upon the temperature at which the filament is operated; it has been the practice to operate carbon filament lamps at such a temperature that this will take from 500 to 600 hours, and the specific consumption expressed in watts per horizontal candle is ordinarily based on such a current consumption that will give this life.

The first incandescent lamps, which were introduced commercially in the early 80's, were made by carbonizing a vegetable fiber, such as a thread or a strip of paper. Weston employed structureless cellulose, producing for the first time a homogeneous carbon filament, which he called "tamedine." He also invented the "flashing process," now generally used, which consists in heating the filament to incandescence in a hydro-carbon vapor whereby a dense carbon coating is deposited upon the filament. This made the carbon filaments much more uniform and marked a decided advance in the incandescent lamp. Edison developed the bamboo filament and used this for a number of years. Later all carbon filaments were made by squirting through a die a thick solution of cellulose made from substances such as cotton, then treating, carbonizing and flashing, and this is the method generally employed to-day.

The early carbon filament lamps required 5 to 6 watts per candle, but improvements in the manufacture of the filaments had improved this specific power consumption to 3.1 watts per candle by about 1888. The high efficiency lamps, having a specific consumption of 3.1 watts per candle, could, however, only be used on circuits having close voltage regulation, as otherwise the life of the lamp was greatly reduced. No radical improvements in carbon filament lamps

were made for over fifteen years until about 1905, when the metallizing or graphitizing process for treating carbon filaments was developed. This process consists essentially in subjecting the carbon filament to the high temperature of an electric furnace with the result that the filament is partly or wholly graphitized. The filament is then "flashed" and subjected to the electric furnace for a second time. The graphitized or metallized carbon filament lamp, known also under the trade name of "Gem lamp," has a specific power consumption of 2.5 watts per candle, with the same normal life as is obtained with the ordinary carbon filament lamp. A further remarkable change produced in the carbon filament by the metallizing or graphitizing process is changing the temperature coefficient of resistance from negative to positive, so that the treated filament behaves in this respect like a metal. This positive temperature coefficient makes the lamp much less influenced by fluctuations in the supply voltage.

(To be continued.)

FITTING ELECTRIC BELLS.

HINTS FOR THE AMATEUR ELECTRICIAN.

BY CLARENCE BIGGS.

The task of fitting a simple electric bell system in a house, whether it be as an ordinary door bell or for signaling in case of burglars or fire, is one which any inexperienced person can easily undertake; and when once the principle which underlies the action of the electric current is clearly understood, it becomes possible for even an elaborate installation to be undertaken. In ordinary houses where the bell is operated by means of a push from the front door, we have what is perhaps the simplest electric bell system possible. This consists of (1) a battery cell, (2) a vibrating bell, and (3) a push, and when these are connected up with a metal wire in a well-known and recognized manner then, when the push is pressed, the electric circuit is "closed" and the bell starts ringing.

TYPE OF BATTERIES.

There are many types of batteries which will answer the purpose of ringing electric bells, but the one universally adopted is that known as Leclanché (named after the inventor), a single quart cell of which is sufficient to operate a small bell when the distance traversed by the wire is not very long. An illustration of a Leclanché cell is given in Fig. 1, and it consists, as shown, of an outer glass jar, usually square, containing an inner porous cup, *A*, and a zinc rod, *B*. The porous cup contains a carbon plate, *C*, with a leaden cap and around the plate is tightly packed a mixture of equal parts of crushed carbon and peroxide of manganese—without dust—while the outer cell contains a sal-ammoniac solution. With a cell thus made, chemical action takes place when the carbon plate and zinc rod are joined by a wire, setting up an electric current, and this is the force which is of such use in the electric bell systems of the present day.

The reason why this type of battery (two or more cells usually being spoken of as a battery) is so extensively used, is on account of its giving the least trouble, and further, the cheapness of its maintenance.

Another type of battery, which is useful in giving an intermittent current such as required for electric bells, is the so-called dry battery, and this kind is undoubtedly best when the battery is liable to much vibration, or in warm climates; they are not, however, so suitable for heavy work or continuous action.

THE BELL.

The type of bell required is so well known that little description is necessary, but few ordinary people seem familiar with its action, and as this knowledge is necessary, should slight adjustments or repairs be

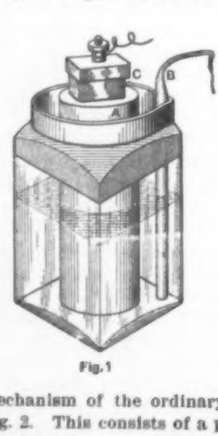


Fig. 1

needed, the mechanism of the ordinary vibrating bell is shown in Fig. 2. This consists of a polished wooden back—usually of teak or walnut—upon which is mounted a cast-iron frame, *A*, carrying the bobbins covered with No. 26 B. W. G. silk-covered wire. An armature of soft iron, *B*, is fixed to a steel spring, one end of which touches a platinum point, *C*, and this point is the end of a screw which works in a short pillar connected by means of a metal arm or wire to a terminal, *D*. The second terminal, *E*, is connected to one of the loose wires of the bobbin—either direct or through a metal plate—while the other end of the bobbin wire is either directly connected to the armature spring, or to the metal base plate, as shown.

The action of the bell is as follows: When the circuit is closed, a current of electricity is generated from the battery and flows through the wire in at terminal, *E*, thence it flows through the wire round the bobbins, and in doing so the soft iron cores inside the bobbins become magnetized and attract the

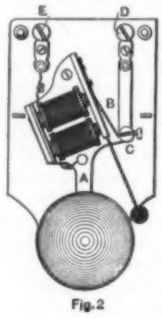


Fig. 2

Fig. 3

Fig. 4

armature, *B*, causing the hammer to strike the gong a smart tap. When this occurs, the spring on the armature ceases to make contact with the platinum point, *C*, thus breaking the circuit and allowing the armature to fall back again. The circuit is again closed, another tap occurs, and thus a continuation of these taps causes the vibrating sound of the bell we hear. The usual sources of weakness in cheap bells are the springs and contacts; the springs should be of tempered steel and plated to resist rust, and the contacts should be of platinum.

The push is used for closing the electric circuit, and when the connections of the battery and bell are in order, the act of depressing the central stud should cause the bell hammer to vibrate. A common form of street door push is illustrated in Fig. 3, with the back or working part shown separately in Fig. 4, which latter is made of a non-conducting material, such as vulcanite, etc., and is screwed in the central part of the frame from the back. The two wires—one from the bell and one from the battery—are passed through the holes, *A*, and the bared ends wound round the screws, *B* and *C*, which are then screwed down tight. When the stud is depressed, the top part of the spring, *D*, is pressed on to the bottom part, *E*, and thus the ends of the two wires are metallically connected together through the two springs *D* and *E*.

Having thus explained the chief features in a simple electric bell system, we will now consider how an electric bell, to be operated by a simple push, is fitted up, and for convenience the case will be taken where the push is fitted to the front door.

THE POSITION.

The first thing to decide is the best position of the bell and the battery. As previously explained, the Leclanché battery requires such little attention it can be put right out of the way, and the place usually selected is on a shelf in the cupboard under the stairs. It matters little, however, wherever it is placed, so long as it is dry and cool, warm or damp places lessening or preventing the action of the cells. For a short distance one quart cell will be sufficient, costing about 60 cents without the solution, which should be mixed in the proportion of 2 ounces sal-ammoniac to 1 pint of water, and the outer cell two-thirds filled. It must be a saturated solution.

The bell should, of course, be put where it is best heard under all conditions, and if it is the only bell in the house, then the hall is usually the best place. The wires necessary for connecting up are made of copper and covered with some non-conducting material and should be placed in such a position that they can be hardly noticed, consequently on the wall under the ceiling or along the skirting boards of a room may be generally regarded as best positions.

It must be remembered that there are two wires running from the street door push, and for convenience these wires are run together side by side as far as possible, as, being thoroughly covered with non-conducting material such as double cotton soaked in paraffine wax, silk, or even India rubber, risk of connection between the wires (called short-circuiting) is avoided. A little wire more or less matters little in the action of the bell, yet it is not advisable to make the path of the wires too long, as they possess a certain amount of resistance to the electric current and obviously the longer the wires the more the resistance.

HOW THE WIRES WILL BE PLACED.

There will be two wires running from the street door, one of which goes to the battery and one to the bell, while a short length will also run from the bell to the battery. These connections may be better understood by reference to the diagram (Fig. 5), where *A* is the street door push, *B* the bell, and *C* the battery, the black lines indicating the wires. In measuring up the wire before purchasing, allow an inch extra for fitting to each terminal and about 2 inches for each wire for connecting to the push. The size of wire used for electric bells is that known as No. 18 B. & S., although No. 20 is often used, but mostly for short lines. The prices vary from 1 cent per yard, according to the nature of the insulation, silk being much higher.

The next step is to mark the position of the push, and this should be about 4 feet from the ground on the door frame. Bore two small holes through the door frame a little distance apart to take the wires, leaving, say, a couple of inches protruding in front. A larger hole can be used to take both wires, if great care is taken not to damage the insulated covering. The ends of each wire must be stripped of their covering for a distance of about 1 inch, then cleaned with emery paper, and the wires passed through the holes, *A*, Fig. 4, the bare ends being wound round underneath the screwheads, as shown. Screw on the outer case, and temporarily fix to the woodwork by one screw, carefully pushing the wire through the frame.

The wires must be run along the wall where convenient, bearing in mind the best positions, as previously stated. One wire must be conveyed to the screwed terminal on the top of the carbon plate of the battery cell, while the other must be taken to a terminal of the bell. The bell and battery must now be joined together by a short length of wire. Refer-

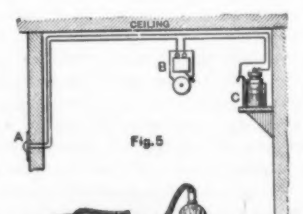


Fig. 5

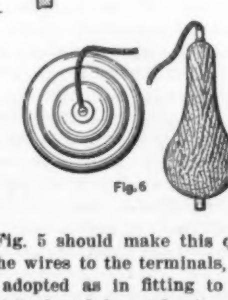


Fig. 6

ence to Fig. 5 should make this quite clear. In connecting the wires to the terminals, the same procedure must be adopted as in fitting to the push, viz., the ends must be bared for at least an inch, cleaned with emery, and then wound round the screw of the terminal and tightly screwed down. This is important, as with bad connections weakness of the circuit, or even failure, is almost bound to occur. When all is connected up, test the bell by depressing the push, and if the wires have been joined up correctly the bell should ring. The front door push can now be screwed up and the wires put straight in position.

In fixing the wires to the wall and woodwork, staples should be used, but great care should be taken so as not to injure the covering, because the staple

being made of metal will close the circuit (short circuiting the current), and thus spoil the system.

In new houses it becomes possible to shorten the length of the wiring by running wires down behind the door frame below the flooring and underneath out of the way; this, however, is not always advisable, as in the case of repair the trouble to get at the wires is increased. When wires are run in walls or behind fixed framework, insulating tubing may be used to take the hidden wires, the ends of the tubing being rounded off to prevent damage to the insulation.

Once the worker has mastered the proper manner of connecting up the wiring, the installation of more complex systems becomes fairly easy, and only needs a little study with pencil and paper to devise some intricate signaling by electric bells.

Before considering more intricate wiring, it may be here remarked that there are various types of pushes besides the one shown, but all work on the same principle as previously described. There is the cheap kind of wooden push, which can be bought for a few cents; the pear-shaped push (see Fig. 6), which is connected to a rosette of wood or other material fixed to the wall. These are useful for operating from the study table, or from the bedside in the case of invalids. There are other means of making contact which are useful in the warning of burglars, or in time of fire, and these will be explained later. All that is necessary in devising an electric bell system is to be able to trace a circuit along a metal wire without a break through the battery and bell when contact is made by means of a push or other device. Take the case of Fig. 7, for example, and it may be remarked that here the battery is indicated by the thick and thin lines marked C and Z, there being two cells shown in this diagram. This is the conventional manner of representing a battery by practical men, and will be adopted in future sketches.

In Fig. 7 the bell can be operated by either of the four switches or pushes, S, and when any one is pressed a complete circuit can be traced from push to battery, battery to bell, and from bell back to switch.

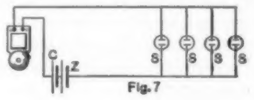


Fig. 7

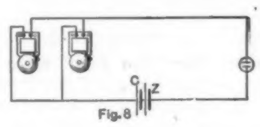


Fig. 8

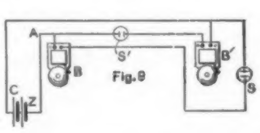


Fig. 9

In fitting up such a system, supposing that the pushes are in separate rooms of a house, the best plan after putting the bell and battery in position is to take the wires from them up to the farthest room, and in so doing run as near to the other rooms as possible, then joining the other wires to them as indicated. As the length of the circuit may be reasonably supposed to be a long one, two cells properly joined together must be employed. The best method of connecting together branch wires will be presently explained. In connecting two or more cells together, a wire must be run from the carbon of one cell to the zinc of the next.

Fig. 8 shows the manner of wiring up so as to ring two bells from one push, and in this case each bell takes half the current. The method of joining up the bells in this case is known as being "connected in parallel," on account of their similar terminals being in direct communication with the same terminal of battery.

In Fig. 9 we have a method of signaling in two directions. When the push, S, is pressed, the bell, B, will sound. This may seem complicated to follow, but in reality it is not so. Suppose, for example, the push, S, is pressed, the current flows from the carbon of the battery right round to the push, S, and through this push to the bell, B, then through the bell to the line, A, and thence round to zinc of battery. In a similar manner when S^1 is pressed, bell B^1 will ring.

In wiring for electric bells, it becomes possible to join wires together so as the current will continue to flow, despite the fact that the wires are broken, and this is especially useful in connecting branch wires, as indicated in Figs. 7, 8, and 9. To connect up the ends of two wires in one straight line, strip off the insulation on each wire for a distance of 1 inch, and clean the bare wires with emery cloth, afterward binding together tightly. The best plan is to cross the wires in the form of a letter X, twisting one wire to the right, and one to the left until a good joint is made. The bare wires should now be covered with a damp-proof insulation, to prevent the copper corroding, which would increase the resistance. The best plan is to solder together, using resin as a flux. Fig. 10 shows two wires connected together in a straight line, and Fig. 11 two at right angles.

With the examples previously explained (see Figs. 7, 8, and 9), it should become quite possible for almost anyone with a little thought to devise many other systems, the method in which the circuit is closed so as to operate the bell being immaterial so long as good contact is made.

Fig. 12, for example, illustrates a burglar alarm contact, and in this the electric circuit is closed when the wires, A and B, are in direct metallic communication, and this only occurs when the top of the spring, C, is touching the metal-topped ebonite block, D.

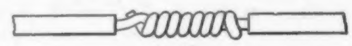


Fig. 10

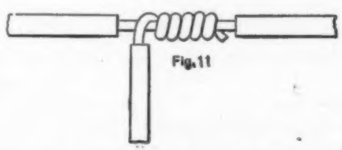


Fig. 11

This device is fitted to the bottom of the window sash, and sunk level with the woodwork so that the end of the marble at E projects slightly as indicated. When the window frame is in position the marble is forced back, and the top of spring, C, kept away from the metal surface of D; thus at night should the window be raised the marble is forced slightly outward, allowing the spring to close the circuit, and thus start the bell ringing.

In connection with burglar alarms, it is far better to employ a continuous ringing bell, so that when once the circuit has been completed, i. e., when the window sash has been raised, the bell will continue to ring, even when the circuit is again broken by closing the window, thus notifying the fact that the window has been once raised. The mechanism of this kind of bell (see Fig. 13) is somewhat similar to the ordinary vibrating kind, but it has three terminals, 1, 2, and 3. The armature is slightly longer than in the vibrating bell, and at its lower end, A, carries a catch which engages a trigger, B. When the circuit is closed, the current passes through the terminals, 1 and 2, and also the coils; thus the cores are magnetized, the armature is attracted, and the trigger released. The spring, C, pulls up one side of the trigger, the other end falls down, makes contact with D, and another circuit is closed; but this time through terminals 2 and 3 (see dotted lines), which entirely excludes the alarm contact, and thus the bell continues to ring until the trigger is restored to its former position by pulling a cord attached at E. This type of bell is also useful for fire alarms when it is necessary that the bell should continue to ring until attention is attracted.

Many types of electrical fire alarms have also been adopted, and the majority of those at present all depend for their efficiency on the fact that heat makes most substances expand, and so causes contact to be made. Others operate by means of a platinum wire being inserted in a thermometer, so that the mercury makes contact with the wire when the temperature rises. Fig. 14 shows one example of an electric fire alarm, and needs but little description. All that is necessary is to fix up the circuit, immerse the device in water at the desired temperature, and regulate the small side screw until the bell rings. Remove from the water, and then it will be noticed that as the metal contracts the circuit is broken, and thus requires the heat of the room to be at the required temperature in order for the bell to ring again.

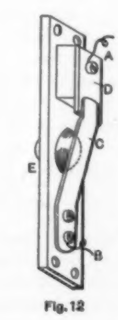


Fig. 12

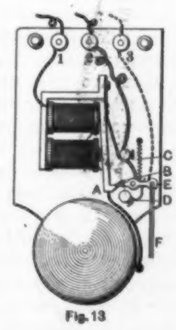


Fig. 13

Fig. 14

It is often necessary to break an electrical circuit, such as for example in burglar or door alarms, during the day time, so that the opening and closing of windows or doors will then not operate the bell. In such cases switches are used, and a simple two-way switch is shown in Fig. 15. One of the wires from the battery connected to the terminal, A, while the other line wires to the studs, B, and so that when the handle is switched over to either stud the particular circuit is closed, and the bell can ring when contact is made either by push window contact, etc. When the handle is on the central pin, D, then communication is broken.

Switches can thus be made to connect up various bells. For example, suppose we have a four-way switch, as indicated at A in Fig. 16, then by connecting up the terminals to the battery, as shown, and the studs 1, 2, 3, and 4 to bells B^1, B^2, and B^3, then by switching the handle over to these studs the various bells can be rung. As shown in the sketch, the circuit is broken, there being no connection between P and either 1, 2, 3, or 4.

When fitting up an electric bell system the use of an indicator is often necessary, showing from what part of the building the bell has been rung. These are somewhat complex in detail, but, as a rule, their principle is exceedingly simple, their action depending upon the current magnetizing two coils. Fig. 17 is a diagram, and will serve to illustrate the principle upon which indicators act. The current enters from A and round coils to B, and in so doing magnetizes them, which attracts one end of an armature, C. The other end of C therefore rises, releases the arm D, which therefore falls to the position, E, and can thus indicate through which set of wires the current passed.

Should the bell wiring and fitting have been properly executed in the first place, the usual cause of a bell not ringing can be traced to a defective battery. In the first place the solution may be exhausted, in which case the best thing is to take out the porous cup and wash the glass cell. Put in 3 or 4 ounces of sal ammoniac, and about half fill with water. Look to the zinc rod, and if crystals have formed on it scrape them off. Return the porous cup and connect up. The liquid in the outer jar should not be more than two-thirds full when the porous cup is in position, or else the sal ammoniac will "creep" over the outer jar. Should this at any time occur, it must be removed, and the top—inside and out—well greased. Sometimes the porous cup gets choked, and prevents the efficient action of the cell, and in such a case the cup should be stood in boiling water for a little time, and then cooled. Should the wires run through a damp place, damp-proof wiring should be employed.

It is always best in fitting up an electric bell system to buy the bell and push, but the handy man can make the battery cell quite easily. First, take a quart jar to serve for an outer cell, and for the porous cup canvas can be used bent in circular form, and provided with a piece for the bottom, coated with melted paraffine wax, and also dip ¾ inch of the top into resin and hot pitch. The outer cell should be coated with Brunswick black at the top. Insert the carbon plate, put in the mixture, adding the zinc and solution; then fit on the terminal. The manganese, carbon, zinc, terminal, and solution can be bought for a few cents. In a future article the subject of fitting up electric light for amateurs will be considered.—Electrician and Mechanic.

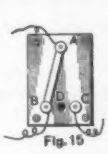


Fig. 15

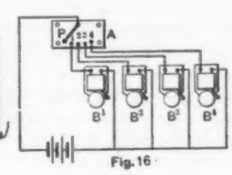


Fig. 16

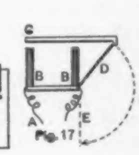


Fig. 17

THE STRENGTH OF RIVETED JOINTS.

IN the Bull. Soc. d'Encouragement, C. Frémont gives the results of his measurements of the strength of riveted joints. He measured the resistance of a riveted joint to slipping by torsion applied about the axis of the rivet. The following conclusions are given: The initial temperature of the rivet is without effect upon the slipping of resistance of the joint, although for other reasons it is preferable to work at a relatively low temperature, e. g., 900 deg. C. The maximum temperature reached by the rivet is, however, of great importance, as overheating will diminish the strength of the rivet even though its temperature be allowed to fall before closing. Joints made with rivets of special steels (nickel and chromium, but chemical composition not stated) had practically no resistance to slipping unless the pressure was maintained for a considerable time (60 seconds) in riveting. This has also been noticed by Mesnager (Ann. des Ponts et Chaussées, 3, pp. 114-141, 1906). Such steels, therefore, offer no practical advantage over much cheaper carbon steels. The resistance to slipping is affected by the state of the surfaces of the plates, although this cannot be adjusted in practice, yet perfect flatness or contact of the parts should be demanded. Contrary to general belief, long rivets give joints with greater adherence than do short ones, provided contact between the plates initially is good. By maintaining the pressure on the rivet during closing, the slipping resistance of the joint can be raised by at least 10 per cent, and sometimes by as much as 60 per cent. A hemispherical head of diameter 2/3 D, where D is the diameter of shank of rivet, is recommended. The edges of the head should be slightly sloped off so as to avoid binding in the die.

ARIDITY AND EVOLUTION.

THE EFFECT OF DRYNESS ON LIFE.

BY DR. D. T. MACDOUGAL OF THE CARNEGIE INSTITUTION.

FROM every excursion which the biologist has made hitherto into speculation as to the origination of living or self-generating matter, and its development into organisms, in which he has called to his support supposed extreme or unusual intensities of terrestrial and atmospheric conditions, he has been ruthlessly recalled by the geological historian with the reminder that the general composition of the atmosphere, its pressure, the temperatures, and other conditions prevalent on the earth's surface were uniform and continuous with those now encountered and not widely different in their total departure in any stage of the earth's development in which life might have originated.

Knowing full well that life did not always exist, that self-generating matter, so far as our observations go, is not now originating, we persistently return to the idea that the beginning of life must have occurred at some stage of the earth's history more favorable to such action than the present.

THE ORIGIN OF LIFE.

In the search for supporting ideas upon which to base speculation, two conceptions serve as encouragement for a renewed attack upon this fascinating problem. One is embraced by Chamberlain's planetesimal theory of the growth of the earth and the attendant modification of surface conditions, which necessarily showed a complex widely different from the present; and the other is one growing in favor with physiologists, to the effect that the essential activities of living matter rest upon catalysis and enzymatic processes, with the characteristic reaction velocities directly affected by internal and external limiting factors.

The protamic nucleus may be taken to represent the first form in which self-generating matter might be said to have the characters of protoplasm; but previously to its synthesis, there must have occurred an increasingly complex series of carbon compounds with hydrogen, oxygen, nitrogen, sulphur, and phosphorus, while iron, calcium, magnesium, and potassium are also involved in its activities at the present time. That these main constituents were present in the atmosphere at partial pressures of varying intensity, and that unstable carbides, nitrides, phosphides, and sulphides brought by infalling planetesimals were passing into more stable unions, with the formation of hydrocarbons, ammonia, hydrogen phosphide, etc., is suggested by Chamberlain; and the possible interactions and combinations might result in the synthesis of very complex substances, well up toward the simpler forms of living matter. The hypothesis formulated by him also assumes that the surface of the earth was unworn piled talus, but little of which had gone into solution. The development of the hydrosphere moistening this layer, and forming pools and small bodies of water all exposed to the light of the sun, together with the variations in temperature, partly due to the heat of impact of infalling bodies, the influence of magnetic fields induced by bodies circulating about the earth would determine the paths of ions and electrons traversing them, while in addition, other states of ionization due to radial activity, would all be possible contributory factors in making a synthesis that might form a beginning of the physical basis of life. Any resulting thermo-catalyzer would be a possible agent for self-organization; and in the development of an organic type, its characteristic activities would consist in the degradation or reduction of the potential energy of the medium or substratum and the oxidation of the acquired substances. Living matter is, in fact, a thermal engine in which the oxidation is, comparatively, exceedingly slow.

EXPERIMENTAL PRODUCTION OF SELF-GENERATING MATTER.

It seems quite probable that combinations similar, analogous, or even identical with the earliest forms of living matter might now be produced in the laboratory, in inclosed spaces or under special conditions. Doubtless compounds of much greater intricacy have been built up; but while we might make such substances, yet it would be extremely difficult for us to furnish the supply of material and the continuance of conditions which would permit this matter to exercise its initial functions to any appreciable extent. The tests and criticisms which have been applied to the results of the few essays that have been made for the production of bodies which would be self-maintenant in a suitable medium, have been for the most part misdirected. Thus in the consideration of the hitherto unsuccessful efforts to produce bodies simulating some of the properties of self-generating matter, tests for the physical and chemical properties of protoplasm, as well as for phenomena of the cell, have been applied, regardless of the fact that the cell probably stands removed by a million years of evolution from the simple living material which first took shape, and represents in fact simply a successful form of organism, and by no means the only possible morphological organization.

PROPERTIES OF LIVING SUBSTANCE.

After growth and decay, the next most important property of living matter is that of irritability, of impressibility and adjustment to environment. The primitive substance of protoplasm endured because of a capacity for withstanding the current range of temperature and insolation, and this endurance was made possible by fairly automatic adjustments, one of the simplest of which is encountered in recognizable form in living plants to-day in the decrease of water content, which follows lower temperatures acting upon protoplasm. Few adjustments are so simple, and of course more complicated ones become possible as atomic group after atomic group was added to the one constituency of living matter.

So far the properties suggested are those common to all living forms, but there must have ensued many differentiations of living matter, of which we have two survivals in those developing into plants and into animals. It seems probable that the first specialization resulted from the formation of substances in some of the living masses which converted radiations of certain wave-lengths into heat and other forms of energy active in promoting the reduction processes. The highest development of this power of absorption of light rays is to be assigned to chlorophyl, but preceding the formation of this very intricate and unstable substance there may have occurred a series of other compounds acting as screens capable of absorbing rays from the lower part of the spectrum, of which the reddish and bluish pigments of the lower algæ are surviving examples. Many disintegration products constituting the reds and blues of plant tissues sustain physical relations of a similar character to sunlight.

ENVIRONMENTAL RELATIONS.

It is not possible to formulate any rational conception of living matter without including its environmental relations. These become of the utmost importance at the moment of formation of self-generating matter; and it may be assumed with perfect safety that of all the possible synthetic processes, only those which ensued in the presence of a medium which furnished substances suitable for building material could survive. Furthermore, when the accumulation of this material and its specialization is considered, it is apparent that successful origination occurred only on solid or semi-solid substrata rather than in undifferentiated solutions in open waters. Still, an abundance of this liquid would be of great importance to the colloidal masses which we may think of as the earliest living things, and as will be shown presently, water has continued to be the most important of all of the constituents of environment, especially with regard to the vegetal organism. The first method of multiplication of individuals or colloidal masses undoubtedly consisted of simple fragmentation resulting from the accumulation of a mass too great to be held together by surface tension, and the separation of these masses must have been accomplished, or made possible, by flotation, which continues to be one of the most efficient agencies in the dissemination of plants, a fact especially emphasized by the results of our studies upon the re-vegetation of the Salton basin.

Wherever portions of the colloidal mass came into contact with solid substances, gelation or aggregation ensued, and the layers of material thus differentiated would give form, and stability in place, representing the earliest form of anchorage organ, which must have been the first member of the vegetative axis to take on definite functions and structure. In this as well as in other features of the plant, evolutionary development was slow so long as the monotonous conditions of an aquatic habitat were to be met.

The present occasion does not permit a discussion of the probable evolutionary development of the vegetal organism from the stage of simple colloidal masses to the gametophyte, and the evidence at our disposal is so entirely lacking that such discussion would be entirely speculative. It will be quite pertinent to call attention to the fact, however, that these earlier rhizoidal anchorage organs stand in no direct or genetic relationship to the roots of modern seed-plants.

THE ORIGIN OF A LAND FLORA.

As has been so succinctly described by Bower, types of vegetation with gametophytic reproduction must necessarily remain aquatic, or at least hygrophilous, since free water was necessary for the movements of gametes in effecting fertilization. Furthermore, the stimulus of desiccation, when such forms were stranded or left above the water level, does not appear to have any direct consequence in the way of development of incidental structures which might facilitate such sexual reproduction, a fact probably due to the morphogenetic limitations of gametophyte, not easily understood.

The problem of aridity was in reality solved in quite another way, by the prolongation of the vegetative existence of the germinating zygospores formed by the union of the gametes, finally resulting in the independent sporophyte. The sporophyte was not dependent upon free water for any part of its existence, and its individual occupation of drier areas was accompanied by a development of the anchorage organ anew, this time from a highly developed shoot-like axis, and the differentiating effects of desiccation upon the root have been scarcely less marked than those of the shoot.

The necessity for anchorage was even greater than before, but now the nutritive salts no longer bathed the entire body, but were present only in hygroscopic layers on the soil particles with a vertical distribution not uniform and with much horizontal irregularity. The formation of absorbing mechanisms and conducting tissues has been followed by a refinement of form and habit reaction in the modern plant as shown by the researches of Cannon, so that in the language of the systematist the appreciable features of the root system doubtless present diagnostic characters quite as marked and as easily recognizable as those of the shoot.

So long as the gametophyte retained its separate existence, however, and depended upon free water for its reproduction, there could be no real land flora, since the plant must stand, as it were, with one foot in the water. The sporophyte waxed in importance unceasingly, however, by the development of the shoot and root systems until its vegetative activity overshadowed those of the gametophyte, its protective tissues finally inclosing the sexual generation, and with the formation of the pollen tube, the seed-plant became wholly able to get away from the stream margin, the low flat moisture-saturated land, and to occupy great continental areas and mountain slopes.

SCARCITY OF FOSSIL REMAINS IN ANCIENT DESERTS.

The total area of deserts at the present time is equal to about one-sixth of the total land exposure, and undisputed evidence is at hand that extended arid areas existed in all of the great geological periods. Since aridity or humidity depends upon topography and the prevailing winds, it follows quite naturally that these ancient deserts did not necessarily occupy positions coincident with the deserts of the present. Thus the facts seem to indicate extensive desiccation in what is now eastern America and parts of Europe in the Lower Carboniferous and Permian, while some coincidence of locality is found in arid areas in Wyoming and Texas. While evidence is accumulating to show that great swings of variations in climate are in progress in various regions, yet it would be difficult to demonstrate the proportion of arid area to the total land area in any previous period, and thus give a quantitative basis for the conclusion that the earth's surface is undergoing progressive desiccation.

It is noteworthy that formations which give evidence of desert conditions are notably free from fossil plants and contain but little in the way of animal remains. At the time of those earlier periods of aridity, vegetation had not developed forms capable of occupying dry land. During the Carboniferous, however, great areas of low-lying land existed in which conditions for gametophyte reproduction were very favorable, and a luxuriant development of ferns and related forms was possible.

ARIDITY, THE MOST IMPORTANT FACTOR AFFECTING THE DEVELOPMENT OF THE PLANT.

The seed-plant with its pollen tube and vascular system may be considered as the major vegetational response to limitations of the supply of moisture, and desiccation has been and continues to be the most important condition affecting the evolutionary development of plants. Temperatures alone have been unduly drawn upon in the interpretation of distribu-

tional features of ancient and existing floras, a fact made more plainly apparent by recent observations at the Desert Laboratory, in which it has been found that several species range over a vertical mile. Such species endure cold of 35 deg. C. and have a growing season of less than a hundred days in the more boreal or alpine portion of their ranges, while in the southern or lower localities inhabited by them, temperatures of 48 deg. C. may be encountered; the growing season extending over 300 days; the thermometer going below the freezing point not more than 12 hours during the entire year.

It is no surprise, therefore, that it is learned that there is no single feature in the structure and functionation of plants that with perfect assurance may be connected with the influence of temperature alone, although alpine and polar floras bear a distinct aspect by reason of a combination of conditions of moisture, insolation, duration of seasons, and course of humidity. While temperature is not in itself a direct factor in shaping the general trend of evolutionary development in plants, yet it is indirectly concerned by the influence exerted upon precipitation, and the relation of the amount of rainfall to the possible evaporation. The great periodic changes in climate, produced by whatever cause, may be taken to have affected vegetation chiefly through the desiccation effects, which not only determined the ranges and habitats of forms, but also played a predominant part in evolution.

(To be continued.)

THE ORIGIN OF THE SATELLITES.*

A NEW THEORY.

BY PROF. T. J. J. SEE.

In a paper presented to this Society January 30th, 1909, grounds were adduced to show that the planets and satellites of the solar system have not been detached from the central bodies which now govern their motions, by acceleration of rotation, as supposed by Laplace, but that all these masses had been captured or added from without, and have since had their orbits reduced in size and rounded up under the secular action of the nebular resisting medium formerly pervading our planetary system. In proof of this view a table was calculated to show the times of rotation of the sun and planets when these globes were imagined expanded to fill the orbits of the bodies revolving about them, according to the mechanical principle of the conservation of areas, in the forms of a criterion proposed by Babinet in 1861. This argument that the planets and satellites have been captured, and not detached, as has been generally supposed since the time of Laplace, is very satisfactory; and to many minds was, no doubt, quite convincing. We shall now give a brief outline of a new proof, referring the reader for a fuller statement to the papers which have been communicated to the Astronomische Nachrichten.

Table showing the application of Babinet's criterion to the planets and satellites when the sun and planets are expanded to fill the orbits of the bodies revolving about them.

Solar System.

Planet	R_p The Sun's observed time of Rev.	P_p Observed period of planet	R_c Time of the Sun's rotation calculated by Babinet's criterion
Mercury	25.3 days = 0.069267 yrs.	0.24085 yrs.	479 yrs.
Venus		0.61237 »	1673 »
The Earth		1.00000 »	3192 »
Mars		1.88085 »	7424 »
Ceres		4.60345 »	24487 »
Jupiter		11.86 »	86560 »
Saturn		29.46 »	290962 »
Uranus		84.02 »	1176765 »
Neptune		164.78 »	2888533 »

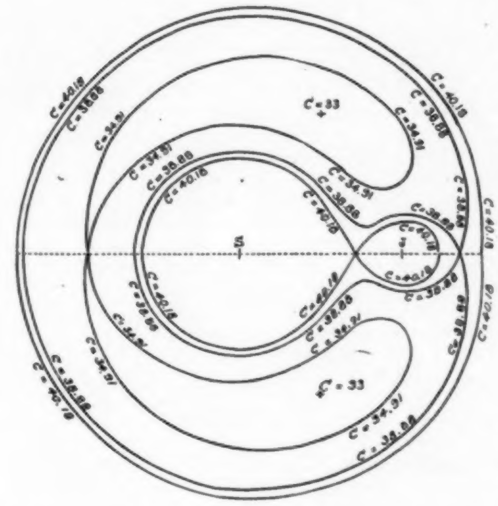
Sub systems.

Planet	Satellite	R_p Adopted rotation of planet	P_p Observed period of satellite	R_c Time of planet's rotation calculated by Babinet's criterion
The Earth	The Moon	1 day	27.32166 days	3632.45 days
Mars	Phobos	24ʰ.62297	7.6542 hours	190.62 hours
	Deimos		30.2983 »	1193.52 »
Jupiter	V	9ʰ.928	11.9563 hours	64.456 hours
	I		1.7698605 days	14.60 days
	II		3.5540942 »	36.900 »
	III		7.1663872 »	93.933 »
	IV		16.7535524 »	290.63 »
	VI		250.618 »	10768.8 »
	VII		265.0 »	11602.4 »
	VIII		930.73 »	61997.2 »
Saturn	Inner edge of ring	10ʰ.641	0.236 days	0.6228 days
	Outer edge of ring		0.6456 »	2.383 »
	Mimas		0.94242 »	4.2902 »
	Enceladus		1.37022 »	7.0615 »
	Tethys		1.887796 »	10.822 »
	Dione		2.736913 »	17.751 »
	Rhea		4.517500 »	34.620 »
Saturn	Titan	10ʰ641	15.945417 days	186.05 days
	Hyperion		21.277396 »	273.06 »
	Iapetus		79.329375 »	1580.1 »
	Phoebe		546.5 »	20712 »
Uranus	Ariel	10ʰ.1112 (cf. A. N. 3992)	2.520383 days	33.714 days
	Umbriel		4.144181 »	65.435 »
	Titania		8.705897 »	176.05 »
	Oberon		13.463269 »	314.83 »
Neptune	Satellite	12ʰ.84817 (cf. A. N. 3992)	5.87690 days	141.8 days

1. In the year 1836 the celebrated German mathematician Jacobi communicated to the Paris Academy of Sciences an integral of the differential equations of motion for the restricted problem of three bodies; the system being made up of a sun attended by a planet revolving about it in a circle, and a particle of insensible mass. Jacobi remarks that the integral may be applied to a body such as the terrestrial moon.

2. In 1877 Dr. G. W. Hill developed and greatly perfected the theory of Jacobi's integral, and applied it to the Lunar Theory in a series of celebrated papers. Hill's work has since been the basis of the profound researches of Poincaré, Darwin, and others on Periodic Orbits and related topics in celestial mechanics.

3. Dr. Hill showed that in the restricted problem of three bodies, implied in Jacobi's integral, there is a partition of the whole space into three parts—one about each of the large bodies, the sun and planet, and a larger domain inclosing both bodies—within which the power or control over the particle is vested in the two bodies individually and collectively, respectively. The closed surface about the earth includes the orbit of the moon, and the orbits of the other satellites in like manner are within the closed surfaces about their several planets; and Dr. Hill remarks that this arrangement is necessary to secure stability (*cf.* Hills "Collected Mathematical Works," vol. i, p. 330).



If a satellite is once within this region with the surface of zero velocity closed about it, it cannot escape, but will always remain attached to the planet, and its radius vector will have a superior limit. How the moon and other satellites came within these closed regions Dr. Hill did not inquire, and subsequent investigators appear to have supposed that as these bodies cannot now escape from their planets, so also conversely they cannot have come in from a remote distance, but must have originated where they now are. This is the view put forth by Moulton in his discussion of Prof. W. H. Pickering's suggestion that Phœbe had been captured by Saturn (*cf.* Astrophysical Journal, October, 1905); but such reasoning is easily shown to be erroneous by the following considerations:

4. Jacobi's integral, as originally given by him, is based on the differential equations for unrestricted motion in *empty space*, and no account is taken of the additional terms which must be added to the differential equation of the motion of the sun, planet, and particle when the motion is conditioned by the introduction of a nebular resisting medium, such as existed in the early history of our system, and is now observed to be widely diffused throughout nature. Jacobi's original integral, therefore, requires the addition of a secular term to represent the actual movement of a sun, planet, and particle; and the complete expression for any particle whose co-ordinates are x, y, z, becomes

$$x^2+y^2+\frac{2(1-\mu)}{\sqrt{(x-x_1)^2+y^2+z^2}}+\frac{2\mu}{\sqrt{(x-x_2)^2+y^2+z^2}}=C+a\,t \quad (1)$$

The secular term $a\,t$ makes the constant increase with the time.

5. Now the surfaces of zero relative velocity, which define the closed spaces about the planets, have larger values of C the nearer we approach to the sun or planet. This is easily seen in the accompanying plate from Darwin's celebrated memoir on Periodic Orbits ("Acta Mathematica," vol. xxi). When the particle or satellite revolves against resistance, therefore, the second member of 1 increases, and there is a secular shrinkage of the surface of zero relative velocity. Accordingly the particle drops down nearer and nearer these centers, and the surface finally becomes closed, leaving it no longer free to move about both bodies, in the hourglass-shaped space, as formerly, but restricted to the sphere of influence controlled by the sun or planet individually as the case may be. The particle which once revolved about both the sun and planet can no longer do so, but becomes an inferior planet or a satellite of the planet.

6. This is how all the satellites of the solar system were captured. At first they moved about the sun, and could pass from the sun's to the planet's domain, through the neck of the hourglass-shaped space connecting the two spheres of influence. When the neck is narrow, Darwin says that a particle which passes from the sun's to the planet's control may revolve about it hundreds of times, before quitting the planet's sphere to return again to the sun's control. And if resistance is meanwhile encountered, so that the neck of the surface of zero velocity becomes closed, it is clear that the particle never will quit the sphere of the planet's control, but will abide there permanently as a satellite.

7. Thus it incontestably follows that the satellites of Jupiter, Saturn, and other planets formerly moved about the sun, and have had their orbits reduced in size and rounded up under the secular action of the resisting medium formerly pervading our solar system. Satellites may cross over the line SJ before coming completely under the planet's control, in which case they will move retrograde. In such cases the neck connecting the two spaces is extremely narrow. But as the neck usually is not so narrow as to produce crossing satellites, most of them naturally move direct, in accordance with observation. This is the reason also why the planets have direct rotations on their axes. Planets have in no case been inverted, as some have recently supposed, in order to account for the retrograde motion of the satellites of Jupiter and Saturn.

8. In the case of the terrestrial moon it is shown that the earth simply captured one of the twenty-seven million such planets which went to form the sun's immense mass. The moon came to us from the depths of space, and never was a part of the earth, as has long been supposed. Prof. Sir G. H. Darwin's celebrated work of 1879 is shown to be based on chance coincidences, and not actual physical history. All the details of the lunar terrestrial system are known to accord with the theory that the moon is a captured planet. a. It is shown by rigorous calculation from the theory of probability that the chances are infinity to one that the moon was captured like the other satellites. b. It is likewise shown that the probability is infinity to one that the earth could not have rotated with sufficient rapidity to detach the moon. As the theoretical possibility of the capture of the moon is beyond doubt, it is therefore certain that it actually occurred.

9. The earth never rotated much, if any, faster than at present, and is a much better time-keeper than has been supposed heretofore. It never had a high degree of oblateness, and changes in rotation have had little if any effect on the events contemplated in geological history.

10. As the moon came to us from celestial space, it was, when first captured, at something like double its present distance; but has since gradually neared the earth. The orbits of the other satellites have been reduced in size and made more circular by the secular

* An abstract of report presented to the meeting of the directors of the Astronomical Society of the Pacific, June 26th, 1909.

effects of resistance, and the same thing has occurred in the case of our satellite. Therefore it is excessively improbable that the movement which has brought the moon nearer and nearer the earth has entirely ceased. It must still be going on, owing to resistance and to the secular increase in the mass of the earth and moon, due to cosmical dust in the form of meteorites. This continued slight secular approach of the moon to the earth is the one known physical cause of the outstanding inequality in the secular acceleration of the moon's mean motion. According to Delaunay, 6.18 sec.* is the amount of the acceleration which can be attributed to the decrease in the eccentricity of the earth's orbit, as explained by Laplace in 1787. The most ancient eclipses indicate an observed secular acceleration of about 10 sec. per century; while the more modern eclipses make it from 8 sec. to 10 sec. Even if the total observed amount of the secular acceleration be only 8.4 sec., as found by Newcomb, there is an outstanding difference of 2.2 sec. The true physical cause of this outstanding difference, whether it be 2.2 sec. or 4 sec., as indicated by the most ancient eclipses, is to be found in the origin of the moon by capture and its subsequent secular approach to the earth. Thus the new theory of the capture of satellites aids us greatly in solving certain problems of the Lunar Theory.

Naval Observatory, Mare Island, Cal.

ELECTRICAL NOTES.

The parallel operation of hydro-electric plants connected by about 500 miles of 44,000-volt three-phase circuits is carried on in Utah and Idaho by the Telluride Power Company. The five generating stations have capacities of 18,000, 3,000, 3,200, 6,500, and 10,800 horse-power respectively and connected with them are seven sub-stations. All stations are or soon will be connected by at least two separate lines, and are so designed that the development of power does not interfere with the use of the water for irrigation.

The use of lignite as fuel in generating stations, states the Electrical Review, is increasing in Germany, where stations continue to be erected in the vicinity of lignite deposits, or the electricity companies purchase the mines or lease the production. Combinations of lignite mines with power stations already exist in the Weissenfels district, at Helmstedt and Schwandorf in the upper Palatinate, and the Electricity Supply Company of Berlin has now arranged with the Hercules Brown Coal Company, of Zittau-Hirschfeld, for the supply of lignite for the overland central station to be erected in Oberlausitz.

The cable-laying steamship "Colonia," of the Telegraph Construction Maintenance Company, of London, which has completed laying 1,307 miles of cable for the Commercial Cable Company from St. Johns, N. F., to New York, is to try to pick up 900 miles of cable that is no longer in use. According to Frank Petley, the engineer, the shore end of the cable weighs about sixteen tons to the mile, while the deep-sea cable, but an inch in diameter, weighs one-eighth as much. In the sweep of the circle made from St. Johns to New York to avoid shoals the cable lies for more than 150 miles in 3,000 fathoms, or 18,000 feet of water.

The June number of Terrestrial Magnetism and Atmospheric Electricity contains a frontispiece showing the magnetic survey yacht "Carnegie" under full sail, and an article describing her construction and the work she is intended to do. She has a displacement when fully equipped of 568 tons, and is built almost without iron, her bolts and metal fittings being of bronze, copper, or gun metal. The observation rooms are amidships. The yacht is to make a magnetic survey of the oceans during the next fifteen years, with the object of correcting the magnetic charts and compass data at present available. Her first voyage will be to Hudson Bay and the North Atlantic Ocean.

An apparatus which is claimed to predict earthquakes has recently been devised by an Italian scientist, A. Maccioni, who presented it to the Siena Academy. Animals, it is observed, have a kind of presentiment of earthquakes and become nervous and excitable. Besides it is known that many persons waken from the soundest sleep an instant before the earthquake shocks although no mechanical movement has been produced. Maccioni supposes that the earthquake center sends out electric waves and these influence the nervous centers. Accordingly he devises an instrument for receiving such electrical waves, using a special coherer which is sensitive to all wave lengths. It is in circuit with a battery and a sensitive galvanometer or relay. From the coherer a wire goes to a metal plate sunk edgewise in the ground. The relay closes the circuit of a strong battery and a registering device, a clock, and a signal bell. The time between the registered signals of the waves and the appearance of ordinary mechanical earthquake shocks as registered in a seismograph is given by comparing the time on the first device with the time shown on the seismograph, which latter is very sensitive. He thus predicted two successive shocks on April 11th of this year, and finds that the time between the arrival of the electric waves and that of the mechanical waves is 4 minutes, with the waves coming from a center lying 14 miles off. Such an instrument may prove to be of value in the study of earthquake phenomena.

* Seconds of arc, not time.

ENGINEERING NOTES.

The discovery of an extensive deposit of fireclay is reported from Monduran Creek, the Narrows, between Gladstone and Keppel Bay, Queensland. The exposed face shows strata of clay extending over a distance of about three chains, while the thickness of the strata from the water level up to the "overburden" of gravel is about 20 feet.

The Soudan is said to be developing steadily and satisfactorily. New parts of the country are fast being opened up through the railways and telegraphs. The great bridge over the Blue Nile at Khartoum is practically completed, and the railway has been continued 70 miles south, as far as Pass Kamber, in Ghezireh. Thence it will run south and west to the White Nile. At Hallat Abbas, on the Blue Nile, 180 miles south of Khartoum, a big railway bridge is in course of construction. It should be completed by the end of next year, at which time the railway is expected to reach there also.

Shellac is the most important and largely applied of all the resins with, perhaps, the exception of colophony. Its most interesting use in India is as a method of decorating articles of wood, metal, and even pottery, which are then known as lac wares. These should be carefully distinguished from the lacquered goods largely produced in Europe and America, in which the lacquer is merely a liquid varnish applied to metallic objects, mainly with the object of preserving them from the action of the atmosphere; and from the true lacquer wares of Burma, China, and Japan, where the varnish used is purely of vegetable origin and is applied in a liquid form. In the production of Indian lac wares shellac, suitably colored, is applied in a solid form, mainly with a view to ornamentation.

The "cow-catcher," or pilot, of American locomotives is an object of derision to European engineers, who regard the presence of a large animal on the track as a possibility too remote for serious consideration. But constructors of locomotives for use in colonial and oriental countries would do well to adopt the American practice. In Siam, recently, two railway accidents were caused by elephants. In one case a train of twenty-seven cars, drawn by two locomotives, was derailed, both engines were overturned and six cars telescoped. In each case the offending elephant was killed by the collision. A German firm, which builds locomotives for the railway from Damascus to Mecca, provides cow catchers of light construction, but strong enough to throw a vagrant camel off the track. The engines of two Algerian lines are also provided with cow catchers.

Silesia this year celebrates its zinc centenary. The first zinc furnace (very primitive) in that country was constructed in 1798, but it was only with improved reduction furnaces in 1809 that zinc could be obtained direct from the calamine. The production that year made 122 tons; it was 1,000 tons in 1816, and 12,167 tons in 1825; thereafter, 40,354 tons were recorded for 1860, 65,663 tons for 1880, and 102,213 tons for 1900. Last year (1908) the production was 141,461 tons, of the value of 55,000,000 marks. If we add the Rhineland and Westphalia production, the German total last year reached 216,000 tons, which gives her the premier position again, which the United States took in 1907. Silesia exports 32 per cent of her zinc to Austria-Hungary, Great Britain, Russia, Italy, France, Denmark, Sweden, the British Indies, China, Japan, Canada, and the United States.

Mineral deposits may be distinguished as superficial, shallow, or deep-seated in the earth's crust; the first of these require no opening up, properly speaking; the second can mostly be opened up by adit levels, while the third class can only be reached by means of shafts. The deepest shafts in the world are in the copper-mining districts of Lake Superior, where there are at least two close upon 5,000 feet in depth; with the exception of this district, of a few shafts in the Bendigo district of Victoria, a few at Johannesburg, and some in the Przibram mines in Bohemia, it may be said that there are practically no shafts in metal mines more than 3,000 feet deep, so that the ability to reach considerably greater depths than have hitherto been attained in most mineral fields may be taken for granted. Indeed, so far as the actual sinking is concerned, there would probably be no serious difficulty in sinking a shaft 10,000 feet deep, provided that it could be known with certainty that a deposit of ore would be met with of sufficient value to recoup the outlay incurred in such a sinking; in other words, the main problems connected with deep sinking are economic rather than technical.

TRADE NOTES AND FORMULÆ.

Soldering Paste.—A solution of waste sheet zinc cuttings in ordinary hydrochloric acid is diluted with an equal quantity of water filtered and ammonia solution added until the deposit is dissolved again. This zinc-chloride-ammonia solution is mixed with thick starch paste, so that a mass of syrupy consistency is obtained, which can be advantageously used in soldering tin-plate, iron, or brass.

Soldering Fluid and Soldering Agent Substitute.—For this purpose an ammonia soap obtained by mixing finely-powdered rosin with strong ammonia solution is used. Of this soap there remains, on the place soldered, only the distributed rosin after soldering. This process is particularly adapted for soldering copper wires together as electric conductors, the rosin acting as an insulation.

Moth-Destroying Preparation.—For furs: 40 parts pure carbolic acid, 20 parts each oil of cloves and oil of lemon, 10 parts of aniline oil, 20 parts essence of mirbane, 3,000 parts alcohol. For cloth garments: 30 parts pure carbolic acid, 60 parts each camphor and oil of rosemary, 10 parts each of clove oil and aniline oil, 500 parts of alcohol. For furniture: Vinegar fumes.

Hard Solders for Mechanicians, Braziers, etc.—

	I.	II.	III.
Copper	....	54.08	....
Brass	81.12	....	3—4
Zinc	18.88	45.29	1

Another difficultly fusible solder that is at the same time malleable and tough and can be worked by hammering, rolling, and brazing, is composed of 78.26 parts brass, 17.41 parts zinc, and 4.33 parts silver.

Soldering fluid can be prepared as follows in a few minutes. Into 500 parts of hydrochloric acid, in a glass or jar, put 250 parts of fine zinc cuttings. It will soon begin to fume and boil, but becomes quiet after a short time and at the bottom of the vessel a black deposit will be perceptible. The fluid should now be poured off into a stone selters water bottle, labeled as to its contents, and the soldering fluid is ready for use. While the fuming is in progress, the vessel must not be covered.

Azo-cerotin pencils are black and colored pencils admirably adapted for the marking of cases, packages, etc., producing marks that can be erased neither by water nor any other fluid and which even resist fairly strong acid. Cerotin (cerotyl alcohol) is obtained from different kinds of wax, especially from Chinese vegetable wax. By melting the wax with hydrate of potash, there is formed cerotinate of potash and ceryl alcohol, which can be obtained by treatment with ether and evaporation of the etherous solution. Cerotin is a crystalline substance, with a greasy feeling, that melts at 79 deg. C. (174 deg. F.), is insoluble in water, but is soluble in alcohol and ether. The cerotin is melted up with some coloring substance and molded into pencils.

Brownish Green Patina on Brass or Bronze.—The carefully cleansed articles are moved to and fro for a few seconds, in a solution made up as follows: In 5,000 parts of water, 10 parts of sulphate of potassium (hepar of sulphur) are dissolved and then so much potash lye added as will cause the solution to feel slightly slimy. Then the articles are transferred to water weakly acidulated with sulphuric acid, but which contains only enough sulphuric acid to impart to the water a faint sour taste. If the articles are drawn through the first fluid, i. e., moved up and down in it, then taken out and transferred to the acidulated water, they will be colored darker. Then scrub them vigorously with the scratch brush, after which a patina will be visible. If a deeper color is desired, continue the process. The articles are again placed in the first fluid and moved to and fro, then immersed in the acid fluid and again scratch-brushed. The color will now be much darker and by repeating this manipulation it can be changed into a dark brown with a greenish cast. One must, however, not neglect the brushing after each dipping, because the object will emerge parti-colored from the solution and the uniform coloring can be produced only by vigorous brushing. The same process can also be applied to brass-coated articles, but the brass coating must not be too thin.

TABLE OF CONTENTS

PAGE